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Development of a Regional Approach to Wildlife Monitoring Related to Energy Exploration and Development in Colorado

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Prepared for BLM by
Natasha Kotliar, Zachary Bowen, Douglas Ouren , and Adrian Farmer,
U.S. Geologcial Survey
Fort Collins Science Center
Fort Collins, CO 80526

Background and Objectives

Recently BLM initiated the development of a National Monitoring Strategy to improve the efficiency and effectiveness of the Bureau's inventory, monitoring, and assessment efforts. The goal of this multi-year effort is to develop an integrated data collection and assessment strategy that will be used to inform and guide land management decisions. The monitoring strategy will include protocols for reporting on resource condition and the effectiveness of management actions at the local, regional, and national levels. As a part of this effort, an evaluation of the Bureau's monitoring efforts in relation to energy development was initiated by an energy team. A subset of the energy team is the Wildlife Regional Energy Monitoring Strategy Subgroup (WREMSS), which evaluated the current data collection process and analysis used to inform managers evaluating activities related to energy development and wildlife resources.

The primary conclusion of the WREMSS was that current monitoring generally focused on compliance and effectiveness monitoring at the local lease level (Falise et al. 2005). WREMSS identified several other issues that limited the effectiveness of current monitoring activities. Frequently, clear monitoring objectives were lacking. Information was incomplete, not analyzed or accessible, or was not used to evaluate or validate decisions or management actions. Inconsistencies among field offices precluded larger status and trend analysis. Finally, current

monitoring does not have a defined link to management and policies because management targets and thresholds have not been clearly defined.

Key Management Questions

The WREMSS identified four key management questions that should be addressed by the BLM monitoring program (Falise et al. 2005):

1. What are the condition and trends of wildlife habitat in basins emphasized in the Energy Policy and Conservation (EPCA) report?
2. What are the stressors or agents of change that affect wildlife habitat in basins emphasized in the EPCA report?
3. Are applied mitigation and best management practices (BMPs) for habitat and human disturbance related to energy development effective in the conservation of wildlife habitat?
4. Are reclamation activities related to energy development accomplishing wildlife and associated habitat objectives as stated in the Activity or Land Use Plans.

Seven-step Framework

To address these concerns, the BLM identified three priority areas (Colorado, Wyoming, Alaska) to develop an approach for monitoring the regional effects of energy exploration and development on wildlife species. Each area will independently develop a monitoring program using a seven-step framework, adapted from Mulder et al. (1999):

1. Specify monitoring goals and objectives
2. Characterize stressors (anthropogenic) that affect the parameters of interest.
3. Develop regional questions and conceptual models to describe how, and through what pathways, anthropogenic stressors affect receptors.
4. Suggest indicators to measure the effects of stressors, and define information availability and needs.
5. Estimate the sensitivity of indicators to detect change, to guide final indicator choice and sampling design.
6. Describe a process by which management can identify thresholds of change requiring a management response.
7. Identify clear connections between the overall monitoring program and the management decision process.

BLM Objectives

By using the seven-step framework, the following objectives will be addressed:

1. Develop a generally applicable methodology for BLM regional monitoring programs using the seven-step process.
2. Implement that methodology to produce a report that prototypes a specific BLM regional monitoring program for the White River and Glenwood Springs Field Offices.
3. Provide BLM with feedback and recommendations based on the experience of developing the methodology and applying it to a specific region.
4. Develop recommendations that will aid BLM in selecting indicators and adopting appropriate thresholds for management response.
5. Recommend how the product can be integrated within the land use planning process.

Colorado BLM meeting summary

Additional objectives and priorities were discussed at the July 2006 meeting at the White River Field Office, which included ~ 35 representatives from BLM, Colorado Division of Wildlife (CDOW), The Nature Conservancy, and USGS. This was the initial meeting between all interested parties involved in the development of the regional monitoring process related to energy exploration/development. The top wildlife management and monitoring questions identified were:

1. What is the context for evaluating changes (both anthropogenic and natural)?
2. What are the implications of landscape changes for migratory birds, BLM sensitive species, and species of management focus (e.g., big game)?
3. What are indirect effects of energy development, both local and cumulative?
4. How can we evaluate the net loss of *effective* habitat?
5. How can we identify critical habitats (e.g., riparian areas, sage-grouse nesting habitat)?
6. How can we determine if management actions are effective/successful at meeting objectives (e.g., reclamation, road use, repeated disturbance)?
7. How can we monitor if permit holders are complying with stipulations?
8. How do we implement performance-based mitigation and monitoring?
9. How should we monitor invasive species?

Draft Monitoring Plan for Colorado

Here we report on a draft monitoring plan developed for the Colorado pilot area and designed to meet the objectives, criteria, and needs identified by BLM and other stakeholders. The focal area covers the area under the jurisdiction of the White River and Glenwood Springs Field Offices (Fig. 1). This region includes an area of increased energy exploration, the Piceance Basin, which includes the Roan Plateau.

We begin with an overview of recently developed monitoring or assessment frameworks, which we reviewed as a part of developing the draft plan, and highlight the advantages and disadvantages of these frameworks for the BLM approach. Second, we provide an overview of our monitoring plan and justification for the approach we propose. Finally, we present the results of Phase I activities as applied to a demonstration area for the White River and Glenwood Springs Field Offices.

Existing Monitoring Frameworks and Assessments

A number of regional or national programs to monitor natural resource conditions and management activities are currently being developed and initiated by several other federal agencies. To identify opportunities for improved cross-agency coordination, to avoid duplication of efforts, and to learn from the experience of cooperating agencies, we first reviewed the ongoing efforts at a national level by the National Park Service (NPS), U.S. Forest Service (USFS), and USGS. In particular, we reviewed the development of the monitoring program for the Northern Colorado Plateau Network of the NPS (O'Dell et al. 2005) because this area overlaps geographically with the BLM focal area. We also reviewed two ecoregional assessments for sagebrush ecosystems: the Great Basin (Wisdom et al. 2005) and Wyoming Basin (Rowland et al. 2006). Two recent syntheses of conceptual and operational aspects of developing ecosystem monitoring programs and examples from case studies (Mulder et al. 1999, Busch and Trexler 2003) contributed to the development of our draft approach.

Several issues are apparent from a review of the ongoing monitoring programs and assessments. First, developing the programs requires considerable time, expertise, and funding for full

implementation. For example, the program developed by the NPS is not fully implemented, and the completion of the development process by NPS monitoring networks takes several years to complete (http://science.nature.nps.gov/im/monitor/schedule.htm). Indeed, many NPS networks have not yet completed Phase III (Fig. 2). As a result of these substantial efforts, the NPS has built a comprehensive and scientifically sound program, but the development process precludes rapid implementation. Likewise, the USFS approach is comprehensive in the number of wildlife species and the scales surveyed (Manley et al. 2004) and ties into an existing monitoring framework (i.e., Forest Inventory Analysis). Because BLM lacks an existing sampling framework, the costs to implement this type of wildlife monitoring program *de novo* will be sizeable.

Both the NPS Vital Signs Monitoring and the USFS national wildlife monitoring frameworks are **retrospective** in that they are designed as a mechanism to detect changes over time and do not target any specific stressors (Noon 2003). However, the monitoring objectives of the BLM pilot projects are largely **prospective** because they address questions or hypotheses related to known environmental stressors (Noon 2003), namely energy development activities. Prospective monitoring is in essence hypothesis testing, whereas retrospective monitoring is designed to be an early warning of population changes.

Although the final products of the NPS and USFS monitoring programs will be scientifically valid and have a high probability of obtaining useful monitoring data, the comprehensive, top-down approach slows implementation. In contrast, the sagebrush regional assessments (Wisdom et al. 2005, Rowland et al. 2006) were completed more rapidly (C. Aldridge, pers. comm.). Thus, the regional assessments provided valuable guidance for development of a prospective monitoring framework that can be initiated prior to, and in conjunction with, the development of a comprehensive retrospective monitoring program.

Process Overview

To avoid prohibitive start-up costs and time consuming background preparation required to implement a comprehensive monitoring program, we propose an iterative three-phase approach with successive stages building on the information and experience gained from earlier stages

(Fig. 3). In each phase, monitoring is gradually expanded, beginning with an initial emphasis on greater use of existing data and predictive modeling, and ending with a fully implemented and comprehensive program in the third phase. This three-phased approach allows for rapid implementation of a program to assess status and trends, while gradually expanding the scope with feedback from an adaptive monitoring framework and is linked to BLM's fledgling national monitoring program.

In Phase I, an initial status assessment will be conducted by: 1) capitalizing on existing data that are not being used currently, 2) incorporating habitat models as surrogates for costly new field surveys, 3) adding cumulative effects of surface disturbance using GIS capabilities, and 4) identifying critical information gaps that require additional surveys, models, and/or research (Fig. 4). Phase II refines the management/monitoring objectives in response to the results of Phase I. Additionally, Phase II expands the predictive modeling developed in Phase I by modifying or creating new habitat models for priority species, as well as adding or expanding surveys and research to test predictions and assumptions identified in Phase I (Fig. 5). Collectively, the first two phases provide an initial assessment of the current status and trends of energy development and the cumulative effects on wildlife, as well as an in-depth evaluation of the current state of knowledge and data quality. Phase III uses the information derived from the application of Phases I and II to inform the design process and thereby ensure that quality information is available to meet the priority monitoring and evaluation requirements of BLM (Fig. 6).

The seven-step framework (Mulder et al. 1999) will guide program development at each phase (Table 1). Initial identification of objectives, stressors, conceptual models, and indicators will be achieved in Phase I, but will be refined and expanded in Phases II and III. The primary difference between the phases is in the types of activities that are applied to the seven-step framework.

By dividing the process into three complementary phases, the goal is to create an adaptive monitoring process that expands incrementally as knowledge increases including: an understanding of wildlife requirements and ecological system functions; experience in implementing/expanding surveys; and developing testable model predictions. This will allow for rapid implementation of a program that is not prohibitively complex or unwieldy, yet is

scientifically sound and uses the best available information at each stage of development. This process will decrease the likelihood of costly mistakes that are more likely for a more complex and comprehensive monitoring strategy. Finally, it allows for step-wise incorporation into existing BLM protocols without creating unnecessarily complex changes in existing business practices that could excessively burden field office personnel.

For each Phase, we have identified the primary activities, the management and monitoring issues addressed, expected products, and the level of staffing and funding needs associated with the activities (Figs 4-6). We use the seven-step framework to provide more details on the activities associated with each phase.

Phase I: Integrate existing data and models to conduct status assessments

1. Develop, refine, and prioritize initial monitoring goals and priorities. This will involve meetings with representatives from all administrative levels of BLM (field office, state, and national) as well as other stakeholders (e.g., state game and fish agencies, other federal agencies, nongovernmental organizations). Priority scales of analysis will be identified.
2. Identify key stressors. This step will be initiated in conjunction with development of monitoring objectives and conceptual models. Priority stressors for assessment in Phase I should be determined.
3. Develop conceptual models for ecosystem function and anthropogenic stressors. The conceptual models identify the major processes and pathways that may be disrupted by anthropogenic activities and helps to ensure that important indicators are considered during the process of prioritizing the selection of indicators to monitor.
4. Select and prioritize indicators based on the conceptual and stressor models, as well as high priority species identified by BLM. This process will include inputs from state game and fish agencies, and incorporates priorities established by the US Fish and Wildlife Service, USGS, Partners in Flight, and The Nature Conservancy.
5. Sampling design and analysis. This includes several steps:
    a. Compile and evaluate existing data. Existing data will be evaluated for statistical and sampling issues including survey design, spatial and temporal sampling scales

(e.g., resolution, grain, extent), data quality, and sensitivity to detect population changes and responses to anthropogenic stressors.

b. Characterize habitats for priority species and quantify landscape condition. First, existing habitat models for priority species will be evaluated (Fig. 7). Species-level and landscape-level indicators will be developed based on priorities and conceptual models. The potential to characterize/model historical landscape condition (baseline) for status and trend analysis will also be evaluated.

c. Forecast habitat and landscape effects. Future scenarios of energy development, based on short-term and long-term projections, will be used to forecast species and landscape-level cumulative effects.

d. Identify data gaps for design of surveys and research. Key assumptions, other information gaps, and model predictions will be used to identify and prioritize monitoring and research needs.

e. Develop protocols to refine/augment existing surveys based on information priorities.

f. Development of data management framework that includes protocols (e.g., metadata) and data processing for cumulative impact assessments (e.g., GIS Theme Manager; http://science.nature.nps.gov/im/apps/thmmgr/).

6. Establish and integrate management targets. This involves assessment of status and trends for priority species and their habitats, landscape condition indices, relationship of indicators to Land Health Standards.
7. Identification of opportunities to integrate assessments into planning and evaluation procedures (Fig. 9, 10). Alternative management activities (including mitigation, setting restoration priorities, proposed management actions) will be evaluated based on habitat and landscape models

Monitoring issues addressed

A major change between the NPS/USFS monitoring emphasis and Phase I activities is our initial focus on GIS capabilities and habitat modeling. This approach will allow evaluation of cumulative effects beyond individual project areas and "functional habitat" changes that result from negative effects that exceed the actual footprint of surface disturbance. Thus, Phase I is modeled after the process developed for the Wyoming Basin assessment (Rowland et al. 2006). Additionally, the use of metadata for existing surveys will allow better documentation and

transparency of the information used for management decisions. The use of habitat models will allow better assessment of status and trends for species that are currently monitored and to add assessments of high-priority focal species that lack survey data. The GIS capabilities and linkage of indicators to Land Health Standards will allow assessment at multiple spatial scales and across administrative levels to provide improved opportunities for integration of information among field offices.

Expected products

Phase I will provide conceptual models, habitat and surface disturbance maps, indicators of landscape-level effects, identify key information gaps and assumptions, priority survey and research needs, and initial management objectives and targets.

Staffing/funding needs

Because this phase relies primarily on existing data and models, funding will primarily be used for short-term modeling/assessment projects and limited new surveys. Contracting with other government and nongovernment organizations that have relevant expertise (e.g., USGS, The Nature Conservancy/Natural Heritage Programs, Rocky Mountain Bird Observatory) may be an efficient way to achieve many of the activities in Phase I. Ongoing staffing needs will be necessary for maintenance and updating of databases, dissemination of data, and conducting periodic updates of status and trends. Training of BLM staff in the use of the products will be necessary at all administrative levels. Extensive literature reviews and conceptual model development by the NPS monitoring program are available. Consequently, there is a large body of information that can be used in Phase I of this project, thereby increasing program efficiency by capitalizing on the groundwork established by NPS and USGS scientists involved in the NPS monitoring program.

Phase II: Expand predictive capability through modeling, and targeted monitoring/research.

Activities

The activities in Phase II are essentially an expansion and refinement of Phase I.

1. Develop and prioritize monitoring goals and priorities and refine priorities developed in Phase I.
2. Refine conceptual models developed in Phase I.
3. Select additional priority indicators identified, but not modeled, in Phase I. Habitat models will be created or refined for priority species identified in Phase I that currently lack available or sufficiently accurate habitat models.
4. Sampling design and analysis. This includes several steps:
    a. Focused monitoring and research on critical information gaps or to test key assumptions identified in Phase I, will be designed and implemented.
    b. Comprehensive status assessments for priority species of concern will be conducted to guide evaluation procedures and management activities.
    c. Historic range of variation assessments will be conducted (e.g., historical fire regimes for pinyon-juniper cover types) to guide management of landscape processes and refinement of indicators of landscape function. For example, Region 2 of the US Forest Service has conducted such assessment for priority species and dominant cover types (http://www.fs.fed.us/r2/projects/scp/).
    d. Refine vegetation maps (e.g., age class or percent cover class, pinyon/juniper subclasses) using new technology (e.g., Quickbird training of Landsat imagery) for identified management or monitoring questions not addressed or adequately quantified in Phase I, and other priority areas (e.g., Roan Plateau; Fig 8).
    e. Develop simulation models for vegetation change (e.g., succession, disturbance, climate change, management activities) to refine evaluation of potential future energy development scenarios.
5. Establish and integrate management targets. Refinement of condition classes relative to baseline or desired conditions of indicators based on Phase I status and trends assessments. This includes developing linkages between unacceptable condition classes to management goals or actions.
6. Identification of opportunities to integrate assessments into planning and evaluation procedures (Fig. 10, 11). Alternative management activities (including mitigation, setting restoration priorities, proposed management actions) will be evaluated based on habitat and landscape models

Monitoring issues addressed

All steps in Phase I will be updated with new information/analyses. This type of adaptive monitoring framework for priority species is illustrated in Figure 12. A key focus of Phase II is the refinement of management and monitoring questions/objectives based on the results of Phase I assessments; this step is critical in linking monitoring to the decision-making framework.

Expected products

In addition to the status assessments for priority species and historic range of variation, refinement/updating of Phase I products will be developed.

Staffing/funding needs

Funding for additional short-term projects/assessments and longer-term funding for new surveys will be needed. Staffing levels are similar those of Phase I.

Phase III: Implementation of Comprehensive Monitoring Program

Activities

Much of the background work (literature review, conceptual models, cumulative assessments) will be completed and used to inform this phase. The NPS Vital Signs Monitoring Program can provide considerable guidance in this endeavor because they have a well-documented process (available on-line) based on considerable input from broad scientific and management communities with diverse backgrounds. In addition, use of the NPS template provides cross-referenced goals and indicators that will facilitate integration among Department of Interior bureaus. Because the NPS approach also follows the seven-step framework of Mulder (1999), it meets the objectives of BLM (Fig 2). The USFS retrospective monitoring framework (Manley et al. 2004) can also be used to guide the development of national and regional standards for wildlife monitoring. Indeed, both monitoring frameworks were intended to be used by other federal agencies (Manley et al. 2004, O'Dell et al. 2005). The retrospective component of the BLM monitoring program will be emphasized in Phase III, whereas prospective monitoring is emphasized in the earlier phases.

Monitoring issues addresses

Priority monitoring gaps identified in Phases I and II will be addressed. Refinement of indictors developed in Phases I and II will be performed. Additional opportunities for adaptive monitoring and adaptive management (i.e., feedback into monitoring and management activities) will be identified. This phase will provide linkages to regional and national monitoring programs by incorporating priorities outside of the focal field offices. Collaboration in the development of monitoring protocols between BLM, NPS, and USFS will facilitate Department of Interior assessments and management across bureau jurisdictions, and increase data quality by increasing sample sizes, the level of inference, and facilitate cross-jurisdictional assessments and management strategies.

By focusing on retrospective monitoring, Phase III will address an issue identified at the July 2006 Meeker meeting: how can we distinguish between natural variation and changes resulting from anthropogenic activities? This distinction is challenging to resolve, thus retrospective monitoring that is implemented over large spatial and temporal scales (requiring national-level implementation and cross-agency collaboration) is essential for evaluation of this issue.

Expected products

Phase III will result in the production of a scientifically and statistically valid monitoring program that addresses a broad range of BLM objectives. For example, compliance and effectiveness monitoring protocols and standards can be implemented across BLM administrative levels, thereby facilitating evaluation beyond a particular field office. The GIS models and analytic capabilities, particularly when applied to regional (e.g., Southwest Regional GAP; http://ftp.nr.usu.edu/swgap/swregap_landcover_report.pdf) or national (e.g., LANDFIRE, NLCD) vegetation maps, will also allow assessments across administrative (e.g., field offices, state offices, nationally) or ecological (e.g., watersheds, ecoregions) levels (Fig. 9). The monitoring program will incorporate compliance (implementation), effectiveness, and validation monitoring (Busch and Trexlor 2003), as well as provide baseline information and retrospective monitoring to quantify and detect future trends.

Staffing/funding needs

Significant new funding and staffing needs will be required for all stages of data collection and analysis. Coordinators for program development and integration with national BLM programs, status assessments, and evaluations will be necessary, especially beyond the field office level.

DEMONSTRATION OF MONITORING FRAMEWORK APPLICATION

To illustrate how process could be implemented for the pilot area, we conducted a demonstration project. The primary focus was to highlight examples of Phase I activities and conduct a mini-assessment for the White River and Grand Junction field offices.

Caveat

It is important to note that the maps and graphic summaries included in this report are intended primarily for illustrative purposes. In many cases, the models were simplified due to time constraints and have not been validated sufficiently for use in planning or analyses without further peer review and additional evaluation.

Selection of analysis scales

To illustrate how this monitoring framework could be scaled up or down from the two focal field offices, we selected a larger study area encompassing five BLM field offices (including Kremmling, Little Snake and Grand Junction field offices; Fig. 13). We selected two additional scales of analysis: the Piceance Basin and the Roan Plateau (Fig. 13). The Piceance Basin was chosen because it is an area of increased exploration and development of energy resources in Colorado, and overlaps with the White River and Glenwood Springs field offices. The Roan Plateau is nested within both the Glenwood Springs field office and the Piceance Basin (Fig 13); the Glenwood Springs Field Office has recently produced an Environmental Impact Statement and Resource Management Plan for the Roan Plateau, so we selected this area to illustrate how the test application could be used in these types of planning and management activities.

There are many other levels or scales at which analysis and summaries could be performed, depending on the objectives. Our purpose in selecting these scales was to show how the monitoring framework and analysis could be evaluated at several scales, and compared across field offices. We highlight some of the issues that should be considered in selecting: 1) the scales of analysis and 2) how the monitoring variables will be compared across scales.

Step 1. Specify goals and objectives

The results of the initial meeting with the focal BLM field offices can be summarized by three central management issues related to energy development: 1) how can cumulative effects, including direct and indirect effects, be quantified relative to natural variation; 2) how can we implement compliance and effectiveness monitoring (e.g., performance-based) to determine if stipulations are met and restoration/mitigation goals are achieved ; and 3) how do we evaluate the cumulative effects of energy development and mitigation activities on species of management interest or concern? Cumulative effects can include: 1) cumulative habitat alteration across multiple assessment scales (e.g., individual projects or field offices), 2) indirect effects (e.g., increased disturbance or predation associated with surface disturbances), and 3) spatial attributes of surface disturbance (e.g., habitat fragmentation and isolation).

Refinement of BLM Monitoring Objectives

The first step in the seven-step framework, and a critical issue in designing and implementing an effective and successful monitoring program, is to clearly identify objectives (Mulder et al. 1999). Indeed, the lack of well-defined objectives has been identified as a major cause of failure for past monitoring programs (Mulder et al. 1999). Although the BLM has identified broad goals in the Statement of Work and initial meetings with BLM and other stakeholders, these goals need to be translated into more specific questions that can be evaluated using prospective monitoring data (Ringold et al. 2003).

The refinement of specific management questions and policy goals be achieved through structured and iterative interactions between USGS scientists, BLM, and other participants (Ringold et al. 2003), and guided by conceptual models of ecosystem functions and stressors. For example, the broad question "are applied mitigation and best management practices (BMPs) for habitat and human disturbance related to energy development effective in the conservation of wildlife habitat?" (Falise et al. 2005) should be refined into a set of more specific questions. Specification of the particular BMPs (e.g., use of native seed sources), specific wildlife habitat (e.g., sage-grouse food and cover), and particular time scales (e.g., initial establishment of native plants vs. trajectories of vegetation recovery following disturbance) are examples of the level of detail required to design effectiveness monitoring programs (see Table 2 for several examples of specific questions have been identified in meetings and discussions with BLM staff).

A hierarchical framework of goals and specific monitoring questions (Ringold et al. 2003) can link national and regional goals with specific monitoring questions and help ensure that the monitoring program will address key management issues across ecological scales and over multiple BLM administrative levels (See Table 3 for an example developed by White River Field Office). As a part of this process, identification of BLM policy and management scenarios, which are linked to specific objectives, is also required. Collectively, the refinement of specific objectives and elucidation of policy and management strategies will help to ensure that appropriate response criteria and links to decision-making are established.

Steps 2-3. Develop Conceptual Models and Stressor Models

An ecosystem-level conceptual model was developed for the Northern Colorado Plateau Network (Miller 2005, O'Dell et al. 2005), which encompasses the BLM focus area. We adapted this conceptual model for the demonstration project (Fig. 16). This conceptual model provides a general overview of the dominant ecological processes and pathways that should be considered during each phase of development. Because the objective of the monitoring program is wildlife habitat and energy development, we developed a stressor model for the wildlife portion of the overall model (Fig. 17). These two conceptual models provide the context for evaluating and identifying the primary impacts of road stressors on wildlife (Fig. 18, 19). In Fig. 18, the primary components of road impacts, road presence and use, are identified. The road stressor submodel (Fig. 19) specifically addresses the potential mechanisms by which roads can affect wildlife and can be used to guide the selection of indicators. In the demonstration project we focused on habitat loss and degradation, as well as landscape structure, but other indicators (e.g., spread of invasive exotic species, population change, genetic diversity) may be identified in subsequent phases as priority indicators. In addition, processes or patterns from the general conceptual model (e.g., fire effects on landscape structure and dynamics) or other anthropogenic stressors (e.g., livestock grazing) may be added in Phases II or III.

The regional assessments for sagebrush ecosystems of the Great Basin (Wisdom et al. 2005) and Wyoming Basins (Rowland et al. 2006) developed a comprehensive analysis of species priorities, conducted habitat modeling, and developed landscape indicators in relation to energy development, that will provide valuable information for Phase I. The Wyoming Basin assessment also overlaps a portion of the focal area, and can be used to provide information on cumulative

effects at larger scales than the study area. The regional assessments also provided habitat models and useful guidelines for conducting assessments.

Step 4. Prioritize Indicators

The initial meetings with BLM and other stakeholders provided a list of priority species (see Table 3 for some examples). For the purposes of this exercise, we chose two high-priority species (greater sage-grouse, mule deer) that have different management issues, habitat requirements, and information available to illustrate two approaches that can be used to model habitat and disturbance effects. The indicators we chose to evaluate were habitat availability and the effects of surface disturbance on habitat quality and spatial distribution.

We also chose several landscape-level indicators. Because pinyon-juniper shrubland is a dominant cover type in the White River Field Office, we evaluated the effects of road density on the continuity of pinyon-juniper patches. We also conducted analyses of road densities, and spatial distribution of roadless areas for all cover types in the study area.

Step 5. Sampling Design and Analysis

Identify, compile, and evaluate available data.

We have compiled relevant data sets, including both survey data and GIS coverages, and created metadata (in conjunction with the USGS Hydrological Monitoring Team). For the demonstration project we used LANDFIRE vegetation maps (Rollins and Frame, 2006) to model potential habitat. We used LANDFIRE data as opposed to other vegetation maps (e.g., Colorado vegetation Classification Project; National Land Cover Data; Southwest Regap) for several reasons. First, BLM will be using LANDFIRE data products to support BLM land monitoring at a national level. Second, a regular and possibly automatic updating process of data layers in LANDFIRE is planned thereby providing an established process for updating BLM analysis and assessment products for use in monitoring and planning. In addition, LANDFIRE vegetation succession and disturbance histories are being modeled for each of the ecological system classes, which will be useful for assessments and planning. Finally, LANDFIRE provides a consistent mapping protocol across broad scales (e.g., at greater extents than Colorado) so it provides opportunities for consistency of analyses across ecological and administrative boundaries. This

will facilitate scaling up or down analyses and summaries as needed. Additional datasets used for the demonstration project are identified below.

Greater Sage-Grouse Model

The distribution of the greater-sage grouse in the demonstration area was primarily limited to the White River, Little Snake, and Kremmling field offices, and few production areas occurred on Glenwood Springs or Grand Junction (Fig. 21). A small production area occurred on the Roan Plateau, but was located on private lands. Thus we focused our analysis of this species across the entire study area and compared the results among the five field offices. We did not evaluate habitat at the Piceance or Roan Plateau levels.

To model potential and functional habitat for greater sage-grouse, we used the habitat modeling approach outlined in the Wyoming Basin Assessment (Fig. 20) and adapted a greater sage-grouse habitat-disturbance model developed for the Wyoming Basin (Rowland et al. 2006). For the purpose of this modeling exercise, we predicted habitat quality at a regional level (i.e., the entire study area) based on general habitat affinities (i.e., sagebrush cover). The effects of surface disturbance on habitat quality (also referred to as "functional" or "effective" habitat) results from both direct (e.g., habitat loss or "footprint") and indirect (e.g., anthropogenic disturbance). The degree of anthropogenic disturbance is assumed to decrease as a function of distance from the surface disturbance, and as such is evaluated within several distance categories.

The habitat sub-model was used without modification (Table 3). To quantify potential habitat, we used a moving window analysis in which the proportion of sagebrush was quantified (based on LANDFIRE Existing Vegetation Type) in a 3-km (1.9 mi) radius circle surrounding each pixel. Each pixel was classified into one of six cover classes and assigned a score ranging from 0 to 1.0; 0 represented no potential habitat (e.g., no sagebrush cover) and 1.0 represented a high probability of occurrence (Table 3). All sagebrush cover types were included as potential habitat. The highest habitat quality score from the resulting habitat map corresponded quite closely with greater sage-grouse production areas as documented by Colorado Division of Wildlife (Fig. 22).

We modified the Wyoming Basin disturbance sub-model for this application. We included the disturbance resulting from three levels of road use as specified in the original model (interstate, state highway, secondary roads obtained from U.S. census TIGER line files). Because

quantitative information on road use frequency is generally lacking, it is often assumed that intensity of disturbance is greatest for interstates and lowest for secondary roads. Other disturbance variables we included were well pad locations (active, inactive; obtained from the Colorado Oil and Gas Conservation Commission; COGCC) and areas of human development (cities obtained from Colorado Department of Transportation; oil and gas facilities obtained from COGCC). The original model included several additional disturbance factors that we did not include in our disturbance sub-model because we could not obtain suitable input GIS data within the time frame available (e.g., burn areas, campgrounds, communication towers, irrigation channels, landfills, and powerlines).

For each of the variables included in the disturbance sub-model, we modeled functional habitat based on the original distance classes without modification. The breakpoints were loosely based on empirical evidence of disturbance effects and appeared reasonable based on published data (Table 4; Rowland et al. 2006). In contrast, the relative degree of disturbance assigned to each distance class was apparently based on expert opinion rather than empirically derived equations. As a result, the weightings for disturbance effects at very large distances from roads (e.g., > 2 km from interstate highways) seemed unrealistically high and based on limited or questionable evidence (e.g., Connelly et al., 2004; p 13.13-13.14). Furthermore, to combine the disturbance from multiple sources, Rowland et al. (2006) used the maximum disturbance score assigned to each pixel. Consequently, in areas of overlapping disturbances, the lower disturbance scores were not included in their overall disturbance values.

To evaluate the potential consequences of potentially inflated disturbance scores and the use of maximum disturbance scores, we conducted a sensitivity analyses by comparing the maps produced by several approaches (Fig. 23). First, we created disturbance maps for the demonstration area based on the original model (i.e., the original disturbance weights and the maximum disturbance score for each pixel; Fig 23a). Second, we repeated this approach using a modified weighting that reduced the disturbance scores for the larger distance categories (i.e., revised disturbance weightings; Table 4; Fig. 23b). Third, we used an additive disturbance score for each pixel based on both the original disturbance scores and revised disturbance weightings (i.e., summed scores for all disturbance buffers affecting a pixel; Fig 23c, d). It is important to note that both additive and maximum disturbance values are the same regardless of whether there is one or more than one disturbance of a particular type present. For the coarse-level analysis we

present here, we assumed that this simplification would not have significant effects. This problem could be addressed by incorporating an index of road density (Aldridge and Boyce 2007).

We present all four disturbance maps to illustrate some of the potential issues involved in modeling. The original model based on maximum disturbance scores makes it difficult to evaluate additional impacts resulting from new energy development in areas where disturbances previously existed (Fig 23a). Likewise, using the additive scores with the original disturbance weightings resulted in extremely high disturbance scores over much of the demonstration area, making it difficult to evaluate the effects of new development (Fig. 23c). The map derived from maximum values of the revised scores shows very little variation across much of the known greater sage-grouse production areas and had relatively low disturbance scores (Fig. 23b). The sensitivity analysis illustrates how model selection and underlying assumptions may result in dramatically different maps that can greatly affect subsequent analyses and conclusions. The particular model that is chosen will depend, in part, on the objectives and the scale of resolution that is required.

For this exercise, we elected to use the additive disturbance map based on revised scores (i.e., Fig 23d) because it allowed us to: 1) avoid swamping out more significant disturbances at close distances by minimizing the impacts predicted at distances greater than 1 km from roads, and 2) address cumulative impacts from multiple disturbances. This model reflected the greatest amount of variation in disturbance among greater sage-grouse production areas and thus, was more useful for demonstration project (Fig 23d). Each of these approaches has inherent benefits and drawbacks, but we used the map that best illustrates how the modeling approach could be used in assessments and planning activities. Ideally, in a comprehensive assessment (i.e., Phases I and II), expert review and the use of empirical data to evaluate the validity of each approach should be performed prior to using maps for assessment and planning activities.

The differences in habitat quality with and without the disturbance sub-model are very pronounced (Fig. 24). The quantity and connectivity of greater sage-grouse habitat are much reduced when disturbance effects are included (Fig. 24). For all field offices, the proportion of habitat in the lowest quality category increased with a concomitant decrease in the highest quality habitat. This was particularly pronounced in the Little Snake and Kremmling field offices

where the greatest amount of high-quality greater sage-grouse habitat occurs (Fig. 25). These patterns are summarized in more detail for select field offices and the entire study area (Fig. 26). For example, in the Little Snake Field Office, the habitat in the highest three classes decreased from over 35% of the potential habitat to less than 15% as a result of disturbance (Fig. 26a); the Little Snake Field Office accounts for the greatest proportion of greater sage-grouse habitat in the study area (Fig. 24). In the White River Field Office, only the proportion of the lowest quality habitat class increased and all other potential habitat classes decreased (Fig. 26b).

To evaluate the direct loss of habitat resulting from surface disturbance (i.e., surface disturbance footprint) we modeled the disturbance footprint as a buffer 0-45 m from the road or well pad (i.e., the maximum score of 1) and set the disturbance scores to 0 for all other buffer distances. The importance of including the potential effects of disturbance beyond the footprint is illustrated in Figure 23. The potential reduction in the amount of greater sage-grouse due to the footprint is relatively minor, and much less than the potential reduction in habitat quality due to cumulative effects of disturbance (Fig. 27).

Mule Deer Model

We used a slightly different approach to model the effects of disturbance on habitat quality for mule deer. We used Colorado Division of Wildlife distribution maps for mule deer and used two distance classes: 1) < 500 m (non-habitat) and 2) > 500 m (functional habitat). To avoid including small, isolated fragments as functional habitat, we eliminated patches < 50 ha. The distribution maps do not rank habitat quality and simply represent presence/absence data, but also provide information on habitat use (e.g., winter, critical winter, summer). For the initial analysis, we evaluated mule deer winter habitat We only included only two distance classes for disturbance because there is less information on mule deer response to road disturbance, and published results indicate disturbance effects for distances less than 500 m (Rost and Bailey 1979, Fox 1989). This approach was chosen to illustrate how models could be developed when: 1) only presence/absence information is available, 2) habitat quality may be more difficult to assess quantitatively, or 3) information on disturbance effects is limited or lacking.

The Little Snake and White River field offices contain the largest proportion of mule deer winter habitat in the study area (Fig. 28). These two field offices show the greatest decrease in habitat availability resulting from disturbance effects. Comparison of three scales of analysis shows that

habitat greater than 500 m from roads and greater than 50 ha comprises 40% of mule deer winter habitat for both the entire study area and the Piceance Basin, but in the Roan Plateau Planning Area it drops to 23% of winter range due to the high density of existing roads (Fig. 29). It is important to note that the mule deer disturbance model did not factor in road type or frequency of use, which may vary among the different assessment scales. However, the results of this initial multi-scale analysis can highlight areas that need further investigation and more detailed modeling that addresses road size and use intensity.

Landscape Analysis

A goal of the BLM field offices is to develop tools to monitor fragmentation as a consequence of energy development. The fragmenting effects of energy development depend, in part, on the density and spatial distribution of wells and associated roads. In this sense, roadless areas can be considered the fragments, which will decrease in size with increasing road density. Small roadless areas can also become isolated from larger roadless areas as the number and size of roadless areas decreases across the landscape. By quantifying fragmentation, field office staff can evaluate the spatial effects of energy development, in addition to total acreage lost.

Quantifying the effects of fragmentation is difficult for many reasons. Some habitats are naturally patchy and such underlying heterogeneity confounds our ability to quantify fragmentation. Landscapes are also variable in time, and the dynamics resulting from natural processes (e.g., succession, fire, drought) may affect spatial patterns (Fig. 16). In addition to scale dependency issues, fragmentation cannot be quantified by a single index. Furthermore, species vary in their sensitivity to road characteristics such as frequency of use, density, and size (Fig. 18) and some species may actually benefit from roads. Finally, the consequences of fragmentation are poorly understood, which makes it difficult to relate indices of fragmentation to specific effects on ecosystem functions or species responses. The negative effects of fragmentation not only depend on the size and spatial distribution of remnant fragments, but also depends on species sensitivity to the negative effects of roads.

Nevertheless, it is worthwhile to characterize the landscape with and without anthropogenic disturbance at a variety of scales to evaluate the spatial consequences of energy development activities. In addition, many species are not priorities for conservation or management, or do not have sufficient information to conduct the type of modeling activities we conducted for sage

grouse or mule deer. Yet, under NEPA requirements, BLM is mandated to assess potential effects including direct, indirect, or cumulative ecological effects. Thus, characterizing landscape condition will address NEPA requirements and may provide a safety net for species that are not specifically targeted for modeling or other monitoring activities. The successful application this approach relies on the assumption that large, roadless areas are more likely maintain the full range of ecosystem functions (Fig. 16) than small, isolated patches, and consequently will better provide for a wide spectrum of habitat for a diverse array of species.

To evaluate fragmentation, we conducted our analyses at three nested scales (study area, field office, upper Roan Plateau) using several landscape indices. To avoid issues with the underlying spatial heterogeneity we did not partition the analysis by cover type. We varied buffer sizes (i.e., distance from roads) and core area sizes (i.e., minimum area sizes without roads). The sizes of buffers (100m, 250m, 500m, 1000m) and core areas (10 ha, 100 ha, 1000 ha, 10,000 ha) were selected to represent a range of sensitivities to the disturbance and fragmenting affects of roads.

The degree of fragmentation varied by field office and was most evident for disturbance buffers greater than 500 m from roads (Fig. 30). In all field offices, over 80% of the area was at least 100 m from a road. In contrast, the Little Snake and White River field offices had ~20% of the area greater than 1000 m from roads, whereas the Grand Junction field office had the largest proportion of its area (almost 50%) greater than 1000 m from roads (Fig. 30). We examined this in more detail in two buffer sizes (250 m; 1000 m) for the entire study area, by varying the minimum size of core areas (Fig. 31). For both buffer sizes, the total core area was fairly constant up to 100 ha minimum size (250 m buffer: 70%; 1000 m buffer: 30%; Fig. 31a). Despite this constancy, the number of core area dropped dramatically when fragments less than 10 ha were excluded (Fig. 31b) indicating that most of these fragments were quite small and contributed very little to the total area. Relatively undisturbed areas that were both large (i.e., > 1000 ha) and far from roads (>1000 m) represented less than 20% of the entire study area (Fig. 31a). This pattern is also illustrated by Figure 32.

We used the results from the core area analysis based on a 250-m road buffer and minimum patch size of 5000 ha to compare with the distribution of greater sage-grouse and mule deer winter habitat (Fig. 33-34). Very little overlap occurs between these large blocks of roadless areas and important habitat for these species.

Upper Roan Plateau

To illustrate how spatial analysis may benefit in planning and management activities we evaluated the consequences of the Proposed Management Plan developed for the upper plateau in the Roan Plateau Resource Management Plan and Environmental Impact Statement (BLM 2006). The proposed plan calls for a phased development such that the maximum surface disturbance will not exceed 350 acres at any one time (Table 5). Because only 75 ac will be impacted by well pads on the upper rim, the predominant ecological effects are expected to result from road creation and disturbance. Currently, 157 miles of roads exist on the upper plateau. The proposed plan calls for closure and reclamation of 19 miles of existing roads and restricted use on an additional 68 miles (Table 5, Fig. 35).

To evaluate the effects of existing roads and proposed road closures, we conducted an analysis of roadless areas under current and proposed conditions. We assumed that road closures and restrictions on use will decrease disturbance resulting from activities along roads. Although the proposed plan does not allow for additional roads to be built without reclaiming existing roads, the time frame for reclamation (demonstration of 1-5 years duration) is assumed to be insufficient for full restoration to pre-disturbance vegetation structure for most of the cover types present on the upper plateau (e.g., sagebrush, pinyon-juniper, mixed conifer forest). The plan restricts creation of new roads to specific areas, primarily ridgetops (Fig. 35).

We used a disturbance buffer of 500 m. Because of the small size of the upper plateau and the current density of roads, larger buffer sizes effectively eliminated any roadless areas. Currently, roads on the upper plateau exist at fairly high densities (Fig. 36), such that only 10% of the area is greater than 500 m from roads (Fig. 39). Both restricted access (i.e., administrative use only) and full closure increased the amount of core areas; collectively the restrictions and closures will increase total core area on the upper plateau by 31% (Fig. 37-39).

The spatial analysis on the upper Roan Plateau demonstrates how this type of spatial analysis could be used to evaluate the benefits of road closures in the EIS. It also can be used to prioritize areas for road development and closure that minimize decrease in core area. This is based on the assumption that restoration activities will remove or greatly reduce the fragmenting effects of roads. Although effective road closures will reduce or remove human disturbance, restoration of

vegetation communities needs to be monitored over time to assure that vegetation succession continues over time frames longer than 1 – 5 years.

Step 6-7. Response Criteria and Links to Decision Making

Development of response criteria will depend on the management objectives both for a particular project area and at larger spatial scales and administrative levels. There is currently little empirical information to develop specific response criteria. For these reasons, the development of response criteria is best conducted with inputs from many sources including managers and scientists, and will depend on priorities and expert opinion.

The BLM Conservation Learning Network has demonstrated success in creating a transparent process for the development of response criteria. This program is a cooperative effort between BLM and The Nature Conservancy and was developed to assist BLM to develop response criteria for multiple priority species and their habitats. Their approach is useful for developing conservation and management strategies and identifying restoration opportunities. The process is specifically designed to fit within established procedures used by BLM (e.g., tied to resource management plans). The expected products from the learning network include indicators of condition, current condition ratings, desired condition ratings, impact analysis, management strategies, and a monitoring framework. These products are developed in a series of workshops between BLM and The Nature Conservancy. Because there are common themes and approaches to both the monitoring program process we described herein and the BLM Conservation Learning Network, these approaches are complementary.

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Table 1. Relationship between seven-step framework (Mulder et al. 1999) and monitoring plan phases.

Seven-Step Framework	Phase I	Phase II	Phase III
Specify goals	Develop initial goals	Refine/expand goals	Refine/expand goals
Identify stressors	Identify Stressors	Refine/expand stressor to be evaluated	Refine/expand stressor to be evaluated
Conceptual models	Develop conceptual models (ecosystem, disturbance, habitat)	Validate/refine models Develop new models	Validate/refine models Develop new models
Select indicators	Prioritize indicators	Add/remove indicators	Add/remove indicators
		ID priority research and monitoring needs to validate models or address critical monitoring needs	ID priority monitoring needs
Sampling design and analysis	ID and evaluate data available	Evaluate new data sources	Evaluate new data sources
	Assessment scales of analysis	Targeted research design (e.g., validate Phase I models)	Research; baseline, prospective, retrospective monitoring design
	Asssessment design/analysis	Priority retrospective and baseline monitoring design	
	Priority/focal monitoring sampling design		
Response criteria	Establish condition classes for selected indicators	Establish condition classes for selected indicators	Establish condition classes for selected indicators
Link to decision making	Develop management targets and management framework	Develop management targets and management framework	Develop management targets and management framework

Table 2a. Hierarchical monitoring priorities developed by White River Field Office to assess impacts of potential stressors on biological integrity.

Level 1 - Biological Integrity	Level 2 - Habitat Type/Attribute	Level 3 - Potential Stressors	Level 4 - Potential Indicators
Functional Habitat	Mountain Shrubland	Invasive Plants Noise - Vehicle Use/Drilling Habitat Loss - Roads/Pads Livestock - Grazing Intensity	Invasive Plants, Virginia Warbler
	Pinyon/Juniper	Invasive Plants Noise - Vehicle Use/Drilling Habitat Loss - Roads/Pads Livestock - Grazing Intensity	Invasive Plants, Pinyon Jay, Black-throated Gray Warbler, Raptors
	Sagebrush	Invasive Plants Noise - Vehicle Use/Drilling Habitat Loss - Roads/Pads Livestock - Grazing Intensity	Invasive Plants, Greater Sage-Grouse, Brewer's Sparrow, Sagebrush Vole
	Thirteen Mile Tongue of the Green River Formation	Invasive Plants Habitat Loss - Roads/Pads Livestock - Grazing Intensity	Invasive Plants, T&E Plants
Landscape-Scale Connectivity	Habitat Fragmentation, Corridors	Noise - Vehicle Use/Drilling Habitat Loss - Roads/Pads Livestock - Grazing Intensity	Elk, Mule Deer

Table 2b. Hierarchical monitoring priorities to quantify habitat loss and other impacts due to disturbance.

Level 1 - Disturbance	Level 2 - Activity	Level 3 - Potential Impacts	Level 4 - Quantify Impacts
Human Disturbance	Energy Development	Pads	Acres Surface Disturbance
		Roads	Acres Surface Disturbance
		Motorized Vehicle Use	Intensity of Road Use
		Powerlines	Miles/Density
	Livestock Grazing	Alter Vegetation Composition and Structure	Vegetation Composition & Structure
	Hunting	Motorized Vehicle Use	Intensity of Road Use
Natural Disturbance	Wildfire	Alter Vegetation Composition and Structure	Vegetation Composition & Structure

Table 3. Examples of hierarchical goals and monitoring questions identified by BLM national, regional, and field offices staff. General statements can reflect goals and objectives across any BLM administrative level. Specific monitoring questions are necessary to develop effective monitoring programs. Levels 1-4 represent examples of general questions, whereas levels 5-6 are necessary for developing monitoring programs.

Level	Type of question	Statement
1	General	What are the stressors or agents of change that affect wildlife habitat?
2	General	How does energy development affect wildlife habitat?
3	General	What are the implications of landscape changes for migratory birds, BLM sensitive species, and species of management focus (e.g., big game)?
4	General	How does fragmentation by roads affect movements of wildlife?
5	Specific monitoring	How does road presence and use inhibit dispersal of sage-grouse among seasonal breeding habitat?
5	Specific monitoring	How does road presence and use inhibit mule deer movements between winter and critical winter habitat?
6	Specific monitoring	Are there critical corridors used during winter movements by mule deer that are at risk from road presence and use planned for future energy development?

Table 4. Greater sage-grouse habitat sub-model.

Proportion Sagebrush	Score
< 0.05	0
0.05 – 0.25	0.2
0.25 – 0.4	.04
0.4 – 0.55	0.6
0.55 – 0.70	0.8
> 0.70	1

Table 5. Greater sage-grouse disturbance sub-model. The revised scores (in bolded text) were used for the final analysis.

Variable	Value	Original	**Revised**
interstate highway	0 - 45 m*	1	**1**
	45-500 m	0.95	**0.95**
	500-2000 m	0.8	**0.7**
	2000-4000 m	0.7	**0.25**
	4000 - 7500 m	0.2	**0.05**
state/fed highway	0-45*	1	**1**
	45-135	0.9	**0.8**
	135-1000	0.7	**0.4**
	1000-2000	0.5	**0.05**
	2000-3000	0.2	**0.01**
secondary rd	0-45*	1	**1**
	45-495	0.7	**0.5**
	495-1000	0.2	**0.05**
well active	0-45*	1	**1**
	45-1000	0.8	**0.6**
	1000-3000	0.5	**0.2**
	3000-5000	0.2	**0.01**
well inactive	pixel with location*	1	**1**
human impact	pixel with urban, or Colorado Oil and Gas Commission Facilites location*	1	**1**
	45-500 m	0.9	**0.9**
	500-1000m	0.8	**0.6**
	1000-7000 m	0.3	**0.15**

*Used for footprint analysis.

Table 6. Resource Management Plan and Environmental Impact Statement recommendations for Roan Plateau (upper rim/plateau only; total upper plateau = 34,758 acres).

Motorized routes on federal land (currently 157 miles)	138 mi (no net increase; new roads must be preceded by road reclamation to maintain this cap)
Existing road closures	19 mi
Administrative use roads (restricted use)	68 mi
New wells	210
New well pads	13
Total area new well pads	75 ac
Maximum surface disturbance (roads, wells, pipelines, etc)	350 ac at any given time; excess must demonstrate reclamation and indication of recover
Maximum well pad density	1/640 ac
No surface occupancy	21,000 ac
Areas of Critical Environmental Concern	23,000 ac (some overlap with areas of no surface occupancy)
Estimated rate of drilling	2 wells/year
Other constraints on drilling	< 20% slope

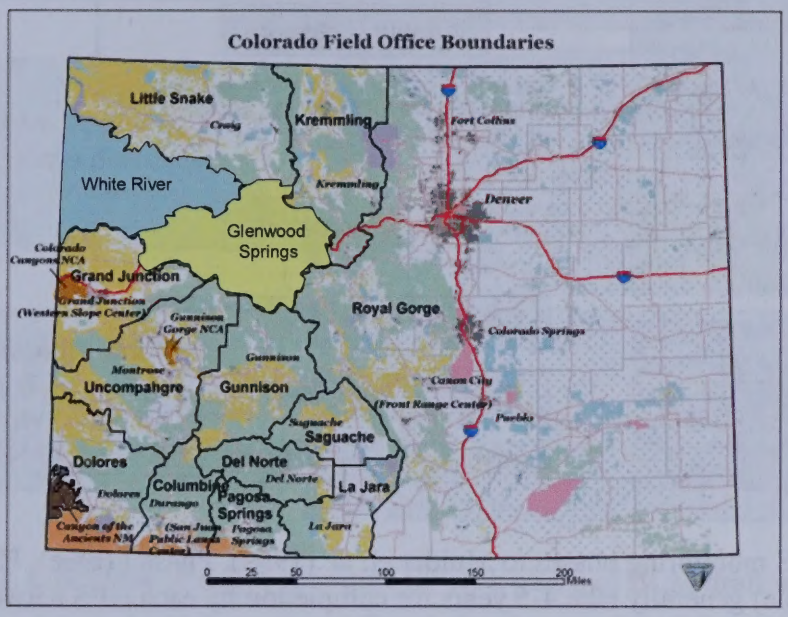


Figure 1. Location of focal area for Colorado BLM monitoring program.

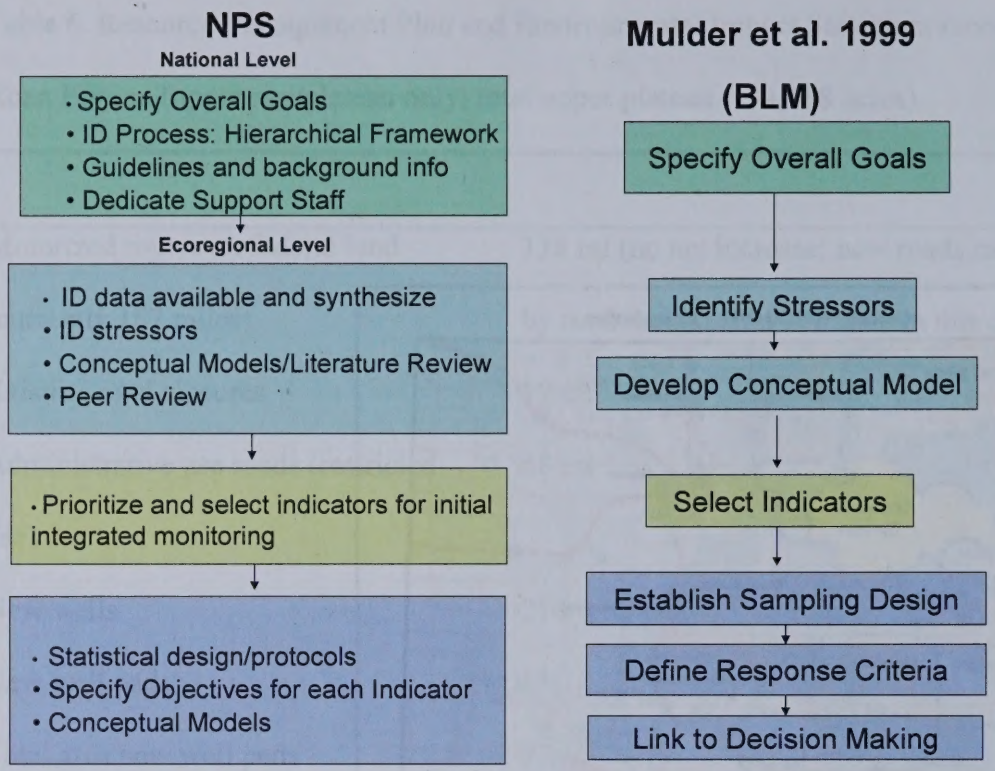


Figure 2. Comparison of NPS monitoring phases to Mulder et. al. (1999). Phase I (blue), Phase II (yellow), and Phase III (purple) generally take 4-5 years for completion by each NPS network.

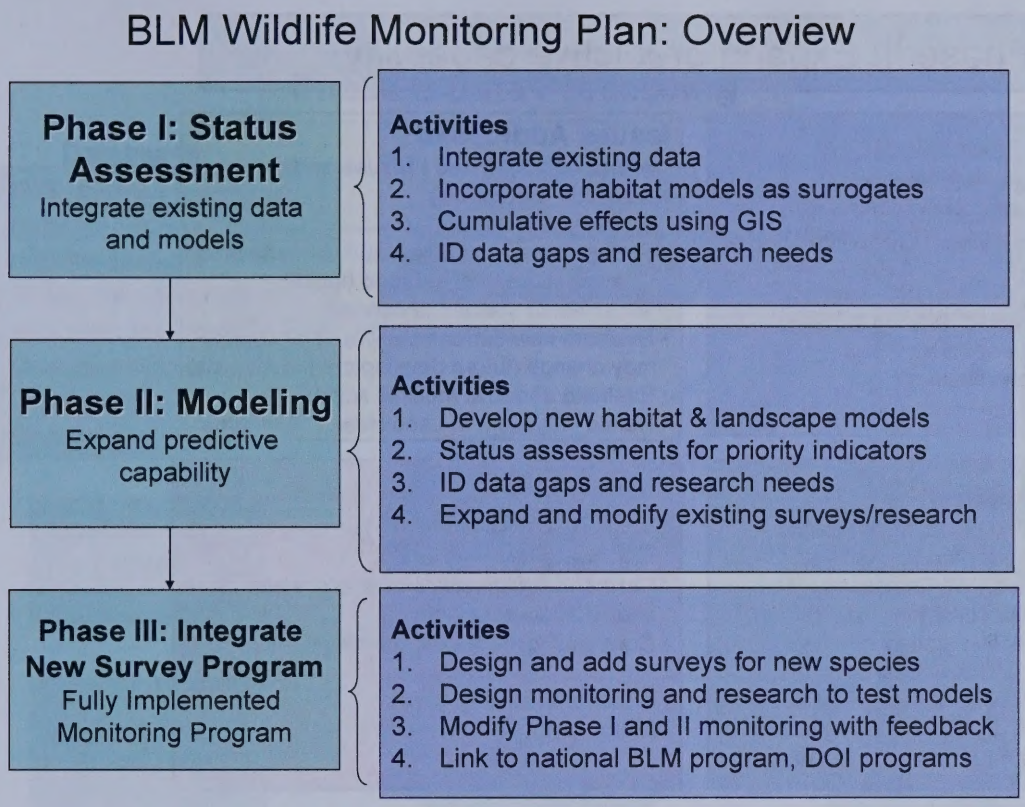

BLM Wildlife Monitoring Plan: Overview
Phase I: Status Assessment
Integrate existing data and models
Activities
1. Integrate existing data
2. Incorporate habitat models as surrogates
3. Cumulative effects using GIS
4. ID data gaps and research needs
Phase II: Modeling
Expand predictive capability
Activities
1. Develop new habitat & landscape models
2. Status assessments for priority indicators
3. ID data gaps and research needs
4. Expand and modify existing surveys/research
Phase III: Integrate New Survey Program
Fully Implemented Monitoring Program
Activities
1. Design and add surveys for new species
2. Design monitoring and research to test models
3. Modify Phase I and II monitoring with feedback
4. Link to national BLM program, DOI programs

Figure 3. Overview of major activities for each phase of BLM draft wildlife monitoring plan.

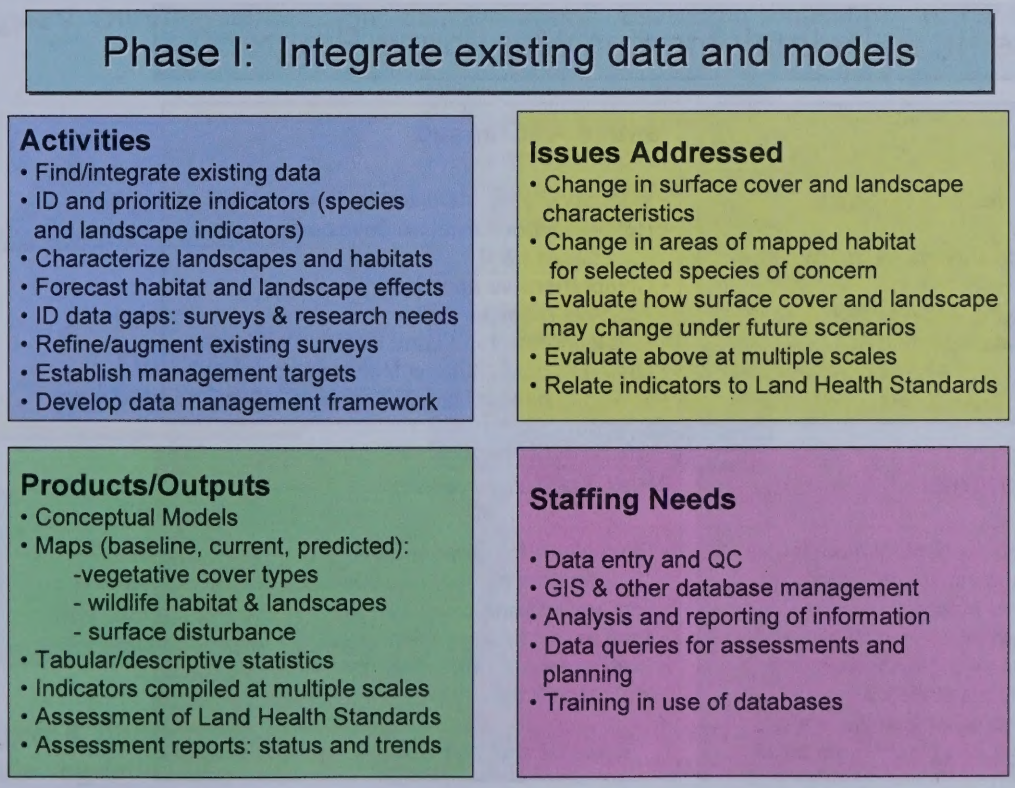

Phase I: Integrate existing data and models
Activities
• Find/integrate existing data
• ID and prioritize indicators (species and landscape indicators)
• Characterize landscapes and habitats
• Forecast habitat and landscape effects
• ID data gaps: surveys & research needs
• Refine/augment existing surveys
• Establish management targets
• Develop data management framework
Issues Addressed
• Change in surface cover and landscape characteristics
• Change in areas of mapped habitat for selected species of concern
• Evaluate how surface cover and landscape may change under future scenarios
• Evaluate above at multiple scales
• Relate indicators to Land Health Standards
Products/Outputs
• Conceptual Models
• Maps (baseline, current, predicted):
-vegetative cover types
- wildlife habitat & landscapes
- surface disturbance
• Tabular/descriptive statistics
• Indicators compiled at multiple scales
• Assessment of Land Health Standards
• Assessment reports: status and trends
Staffing Needs
• Data entry and QC
• GIS & other database management
• Analysis and reporting of information
• Data queries for assessments and planning
• Training in use of databases

Figure 4. Phase I of BLM draft wildlife monitoring plan.

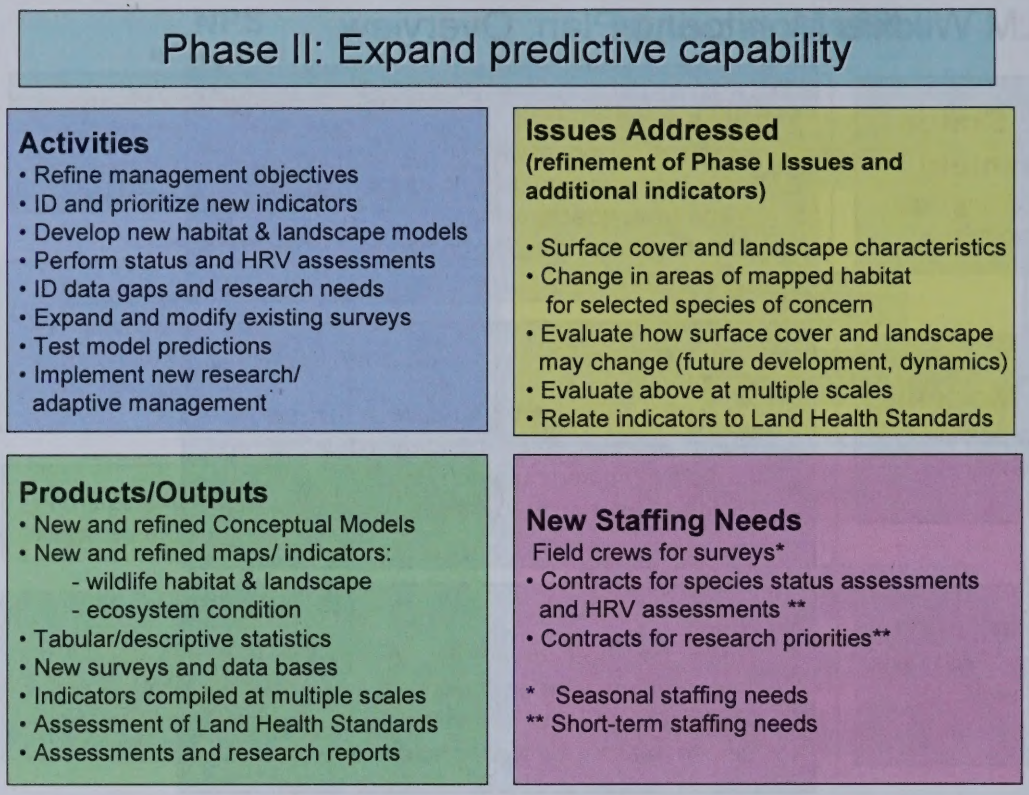

Phase II: Expand predictive capability
Activities
• Refine management objectives
• ID and prioritize new indicators
• Develop new habitat & landscape models
• Perform status and HRV assessments
• ID data gaps and research needs
• Expand and modify existing surveys
• Test model predictions
• Implement new research/ adaptive management
Issues Addressed
(refinement of Phase I Issues and additional indicators)
• Surface cover and landscape characteristics
• Change in areas of mapped habitat for selected species of concern
• Evaluate how surface cover and landscape may change (future development, dynamics)
• Evaluate above at multiple scales
• Relate indicators to Land Health Standards
Products/Outputs
• New and refined Conceptual Models
• New and refined maps/ indicators:
- wildlife habitat & landscape
- ecosystem condition
• Tabular/descriptive statistics
• New surveys and data bases
• Indicators compiled at multiple scales
• Assessment of Land Health Standards
• Assessments and research reports
New Staffing Needs
Field crews for surveys*
• Contracts for species status assessments and HRV assessments **
• Contracts for research priorities**
* Seasonal staffing needs
** Short-term staffing needs

Figure 5. Phase II of BLM draft wildlife monitoring plan.

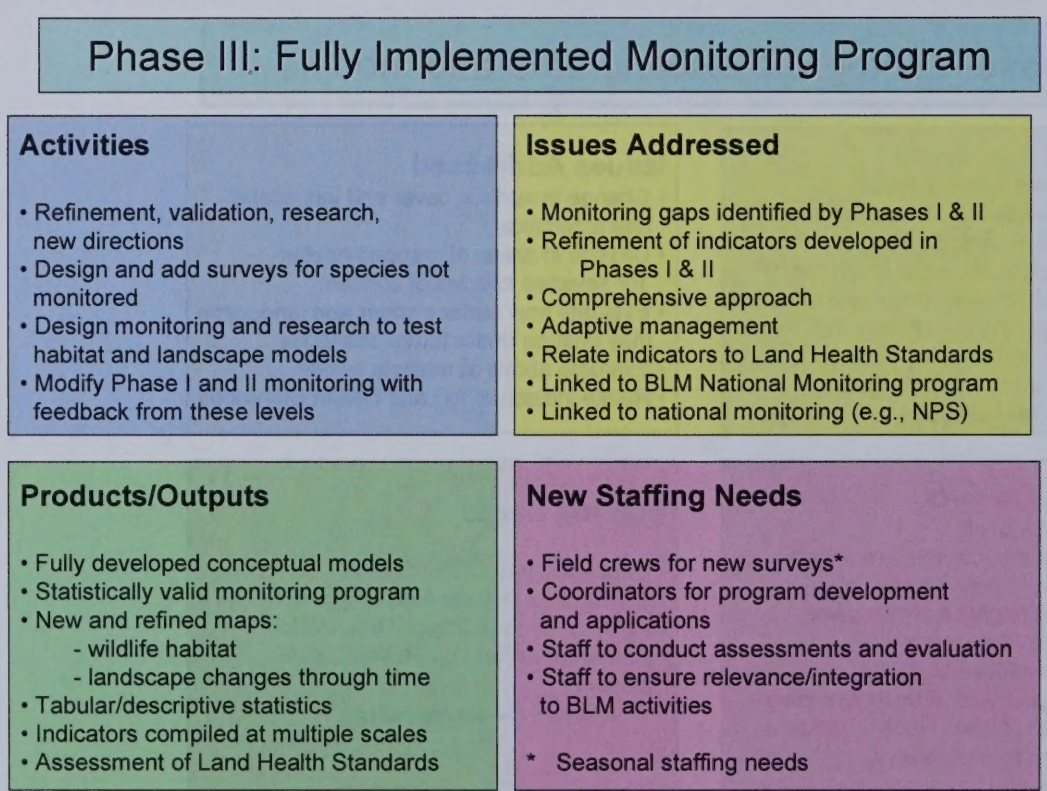

Phase III: Fully Implemented Monitoring Program
Activities
• Refinement, validation, research, new directions
• Design and add surveys for species not monitored
• Design monitoring and research to test habitat and landscape models
• Modify Phase I and II monitoring with feedback from these levels
Issues Addressed
• Monitoring gaps identified by Phases I & II
• Refinement of indicators developed in Phases I & II
• Comprehensive approach
• Adaptive management
• Relate indicators to Land Health Standards
• Linked to BLM National Monitoring program
• Linked to national monitoring (e.g., NPS)
Products/Outputs
• Fully developed conceptual models
• Statistically valid monitoring program
• New and refined maps:
- wildlife habitat
- landscape changes through time
• Tabular/descriptive statistics
• Indicators compiled at multiple scales
• Assessment of Land Health Standards
New Staffing Needs
• Field crews for new surveys*
• Coordinators for program development and applications
• Staff to conduct assessments and evaluation
• Staff to ensure relevance/integration to BLM activities
* Seasonal staffing needs

Figure 6. Phase III of BLM draft wildlife monitoring plan.

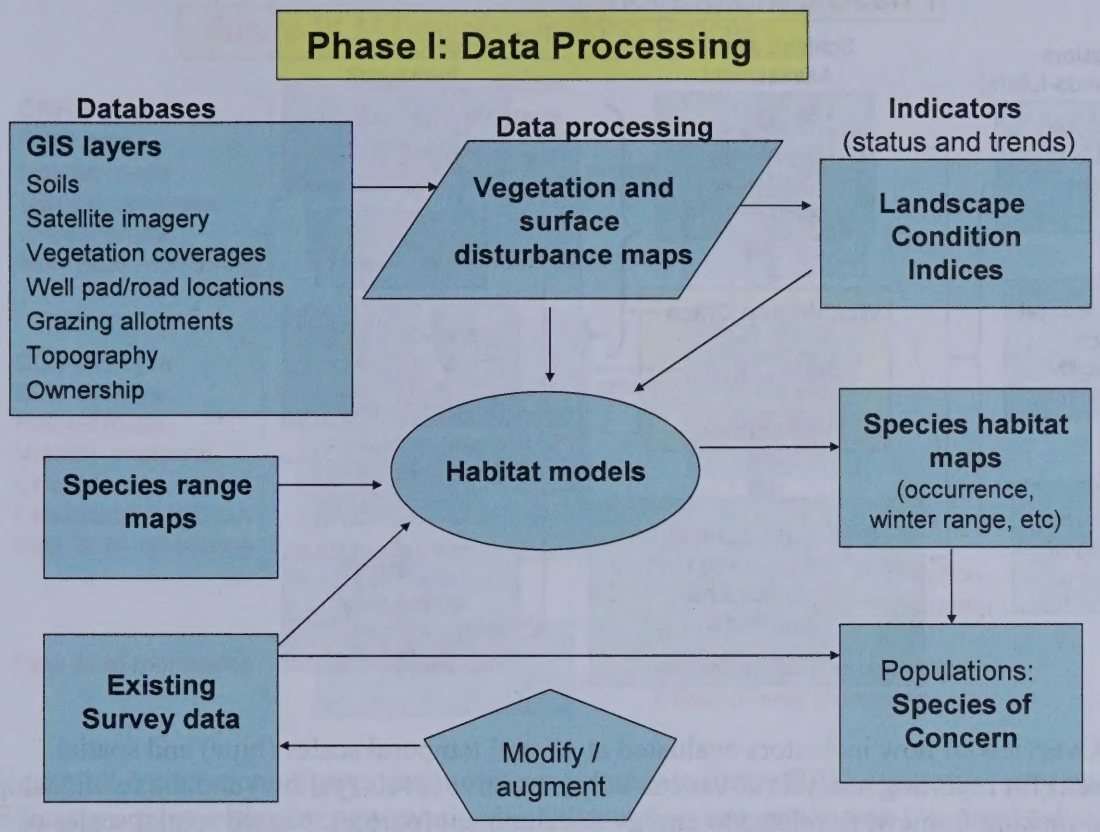


Figure 7. Overview of data input, data processing, and output (indicators) for Phase I activities.

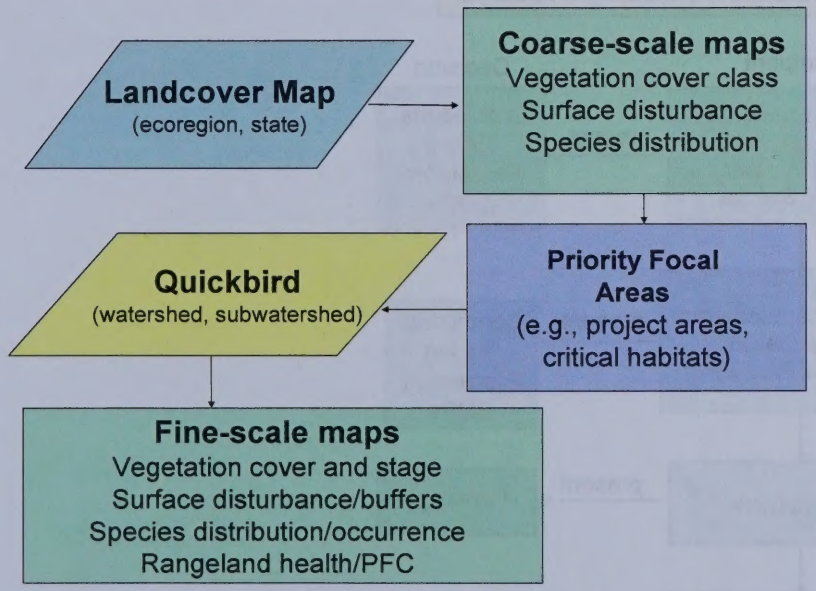


Figure 8. Illustration of a multi-scale approach to landscape and habitat assessments. Coarse-scale vegetation maps allow analysis at larger spatial scales (e.g., state, ecoregions, national). Finer-scaled maps can improve accuracy for specific project areas and management objectives, but currently may be cost-prohibitive at larger spatial extents.

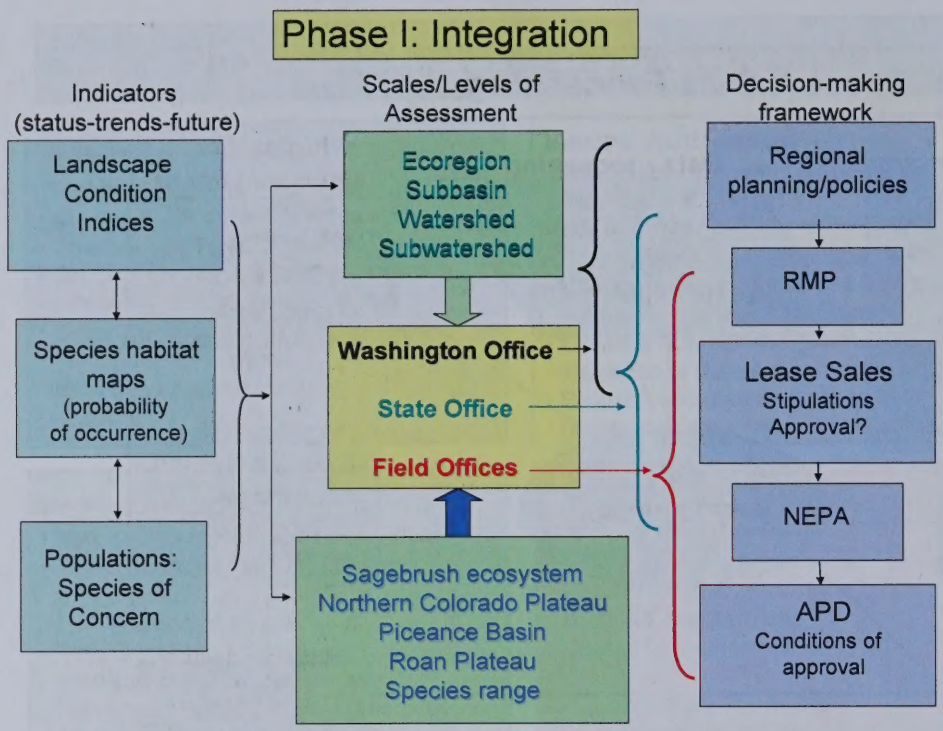


Figure 9. Overview of how indicators evaluated at several temporal scales (blue) and spatial scales (green) for reporting/analysis at various administrative levels (yellow) and the relationship to decision-making framework related to energy development (purple). Nested spatial scales of analysis (e.g., upper green rectangle) or focal scales of analysis (lower green rectangle) illustrate alternative scales of evaluation that can be addressed by this framework.

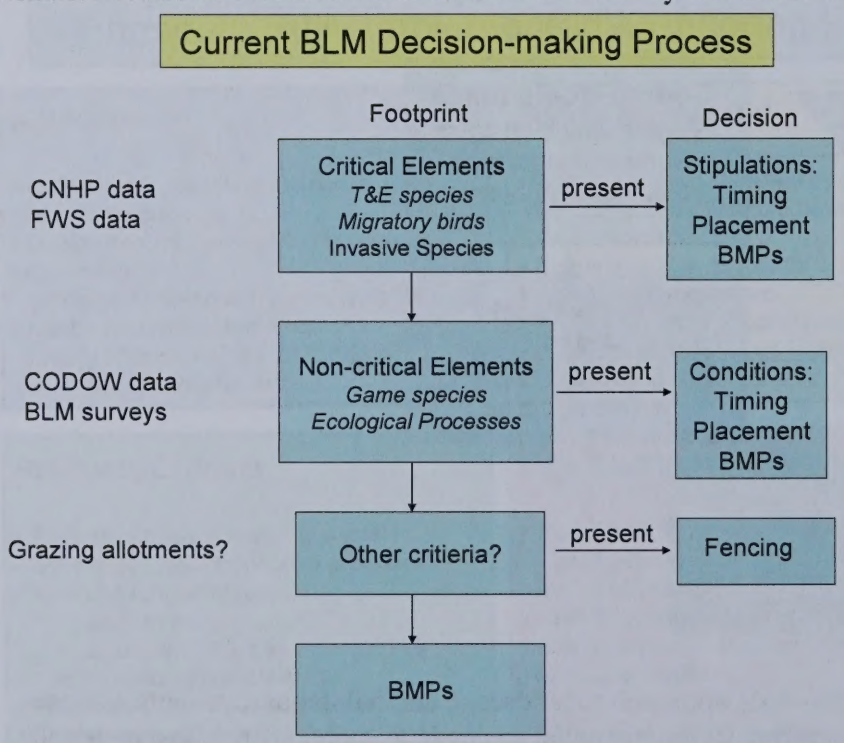


Figure 10. Overview of current BLM evaluation process: examples of data inputs, criteria, and decisions.

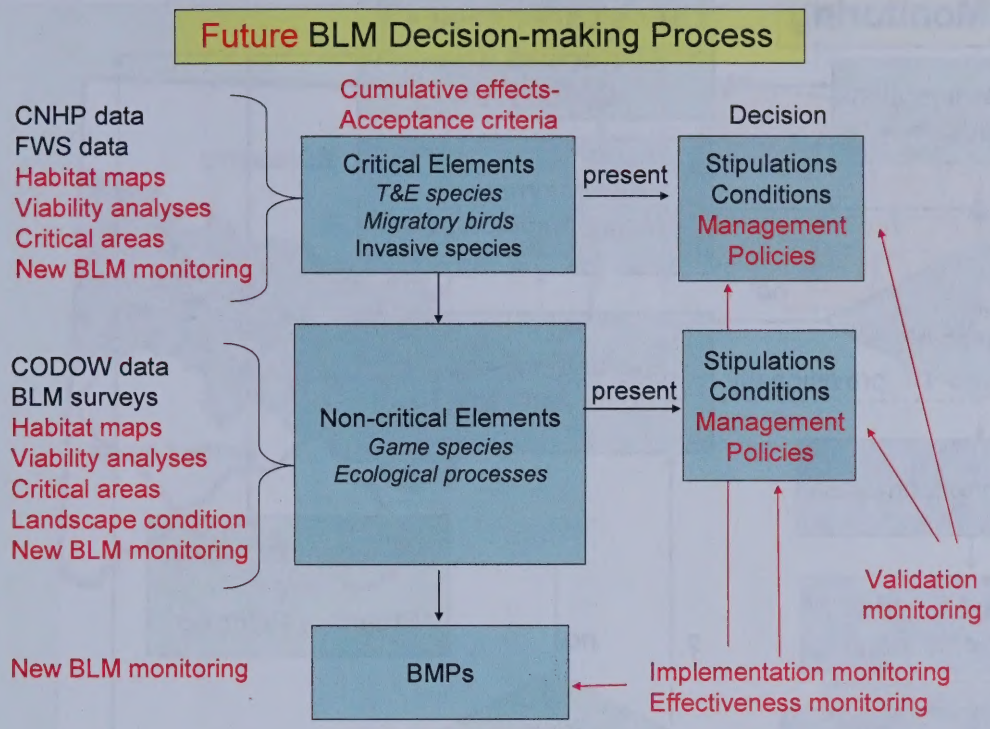


Figure 11. Integration of proposed monitoring data into future BLM evaluation process. Red text indicates opportunities for new monitoring information integration into the current decision process.

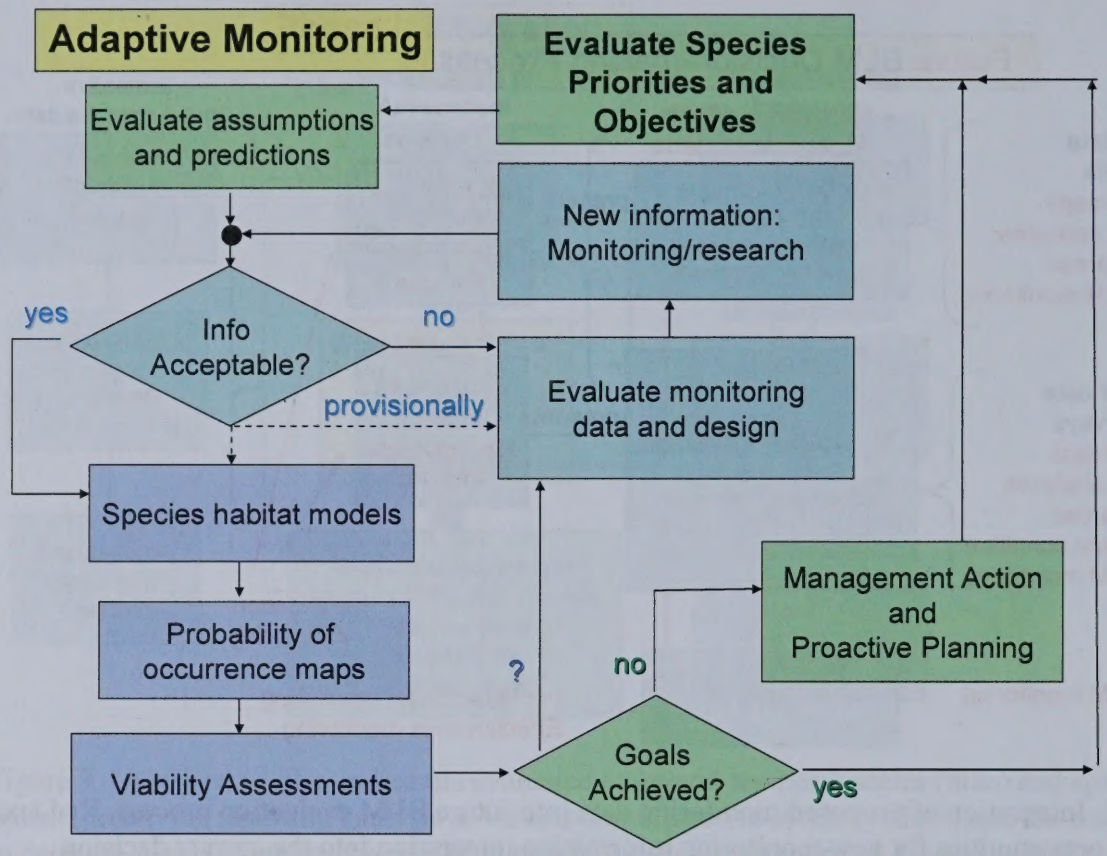


Figure 12. Adaptive monitoring framework illustrated for species-level assessments (adapted from Ringwold et al. 2003). A key component of this framework is the development of management goals, actions, and assumptions to be evaluated (green polygons) based on monitoring data and model predictions (purple rectangles). Management and planning activities will be evaluated if identified goals are not achieved. Information quality and gaps will be evaluated to upgrade the monitoring program (blue polygons).

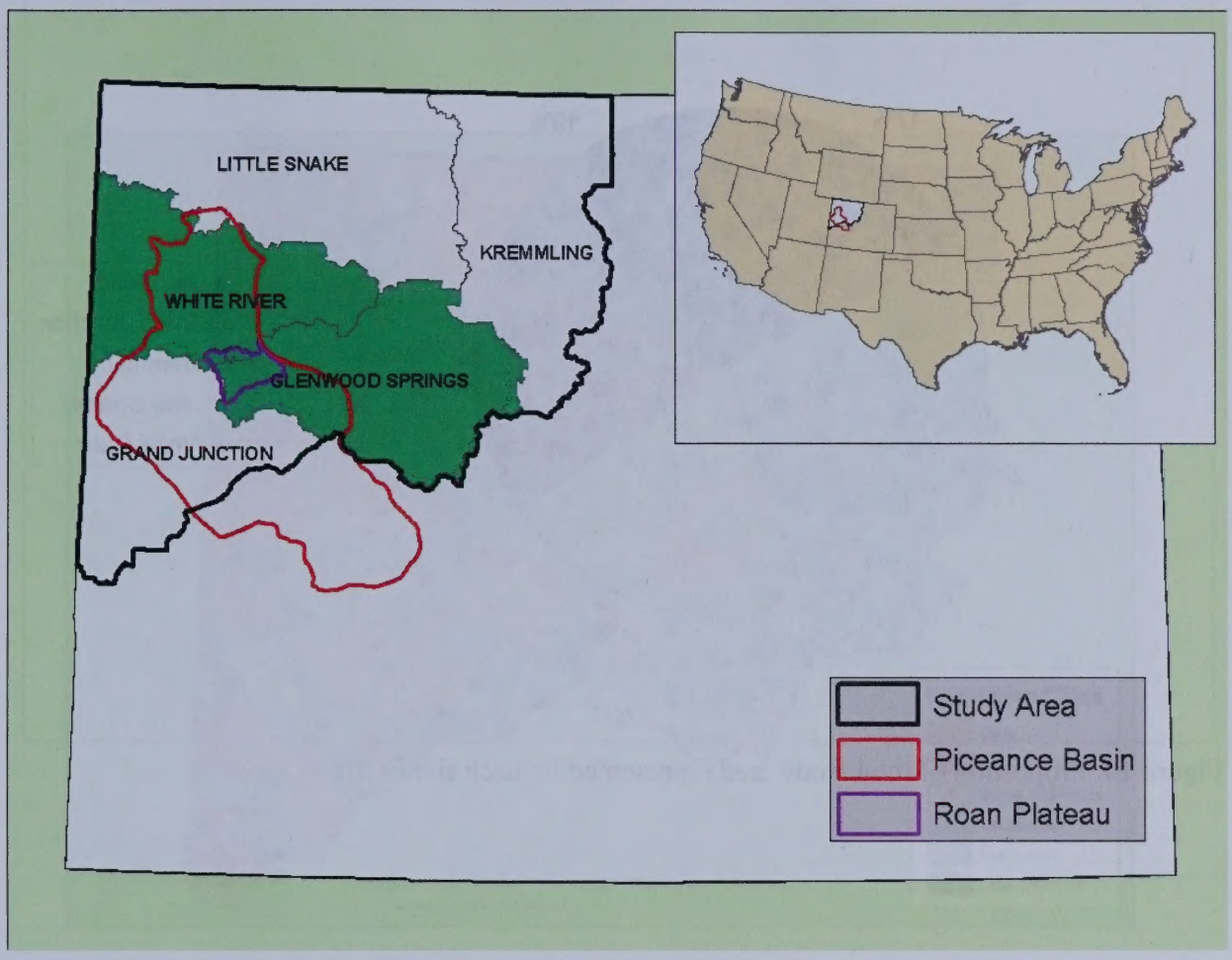


Figure 13. Scales of analysis for demonstration project. Study area refers to the region encompassed by five BLM field offices. White River and Glenwood Springs field offices (in green) comprise the focal area.

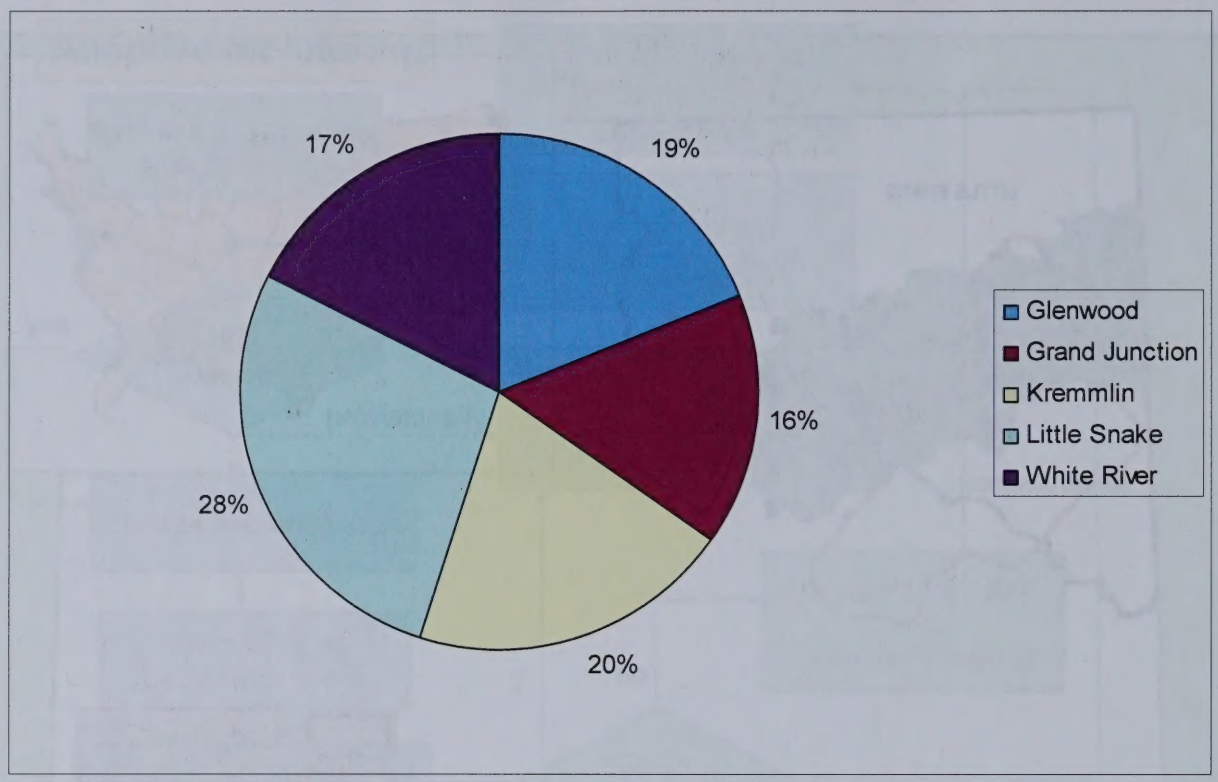


Figure 14. Proportion of total study area represented by each field office.

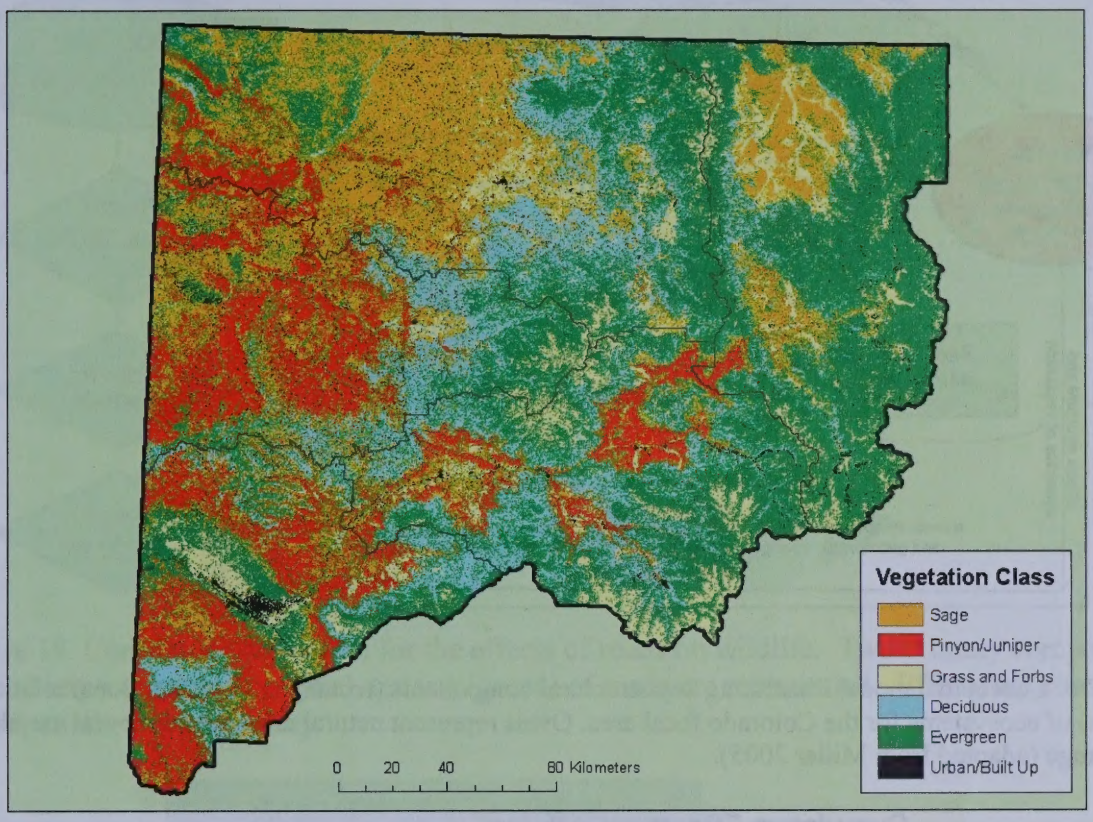


Figure 15. Vegetation map for the study area showing dominant cover classes derived from LANDFIRE vegetation classification. The deciduous cover class includes all woody vegetation (i.e., trees and shrubs).

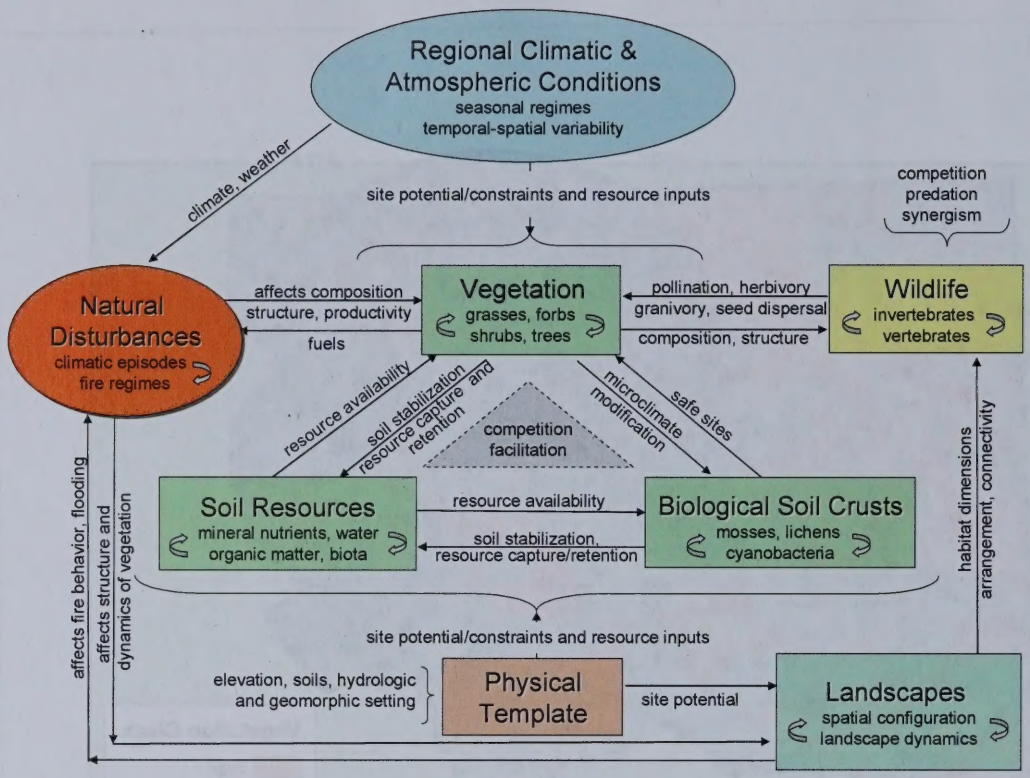


Figure 16. Conceptual model illustrating key structural components (rectangles) and functional relations (arrows) of ecosystems for the Colorado focal area. Ovals represent natural drivers of temporal variability and change (adapted from Miller 2005).

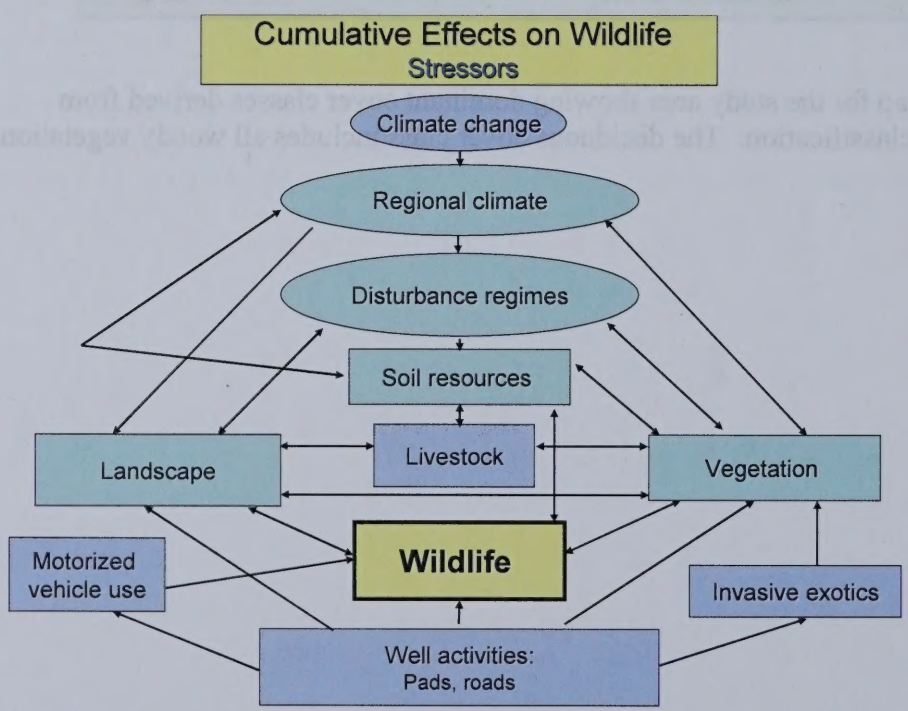


Figure 17. Conceptual model of major anthropogenic stressors affecting wildlife on BLM lands. Stressors are indicated in purple.

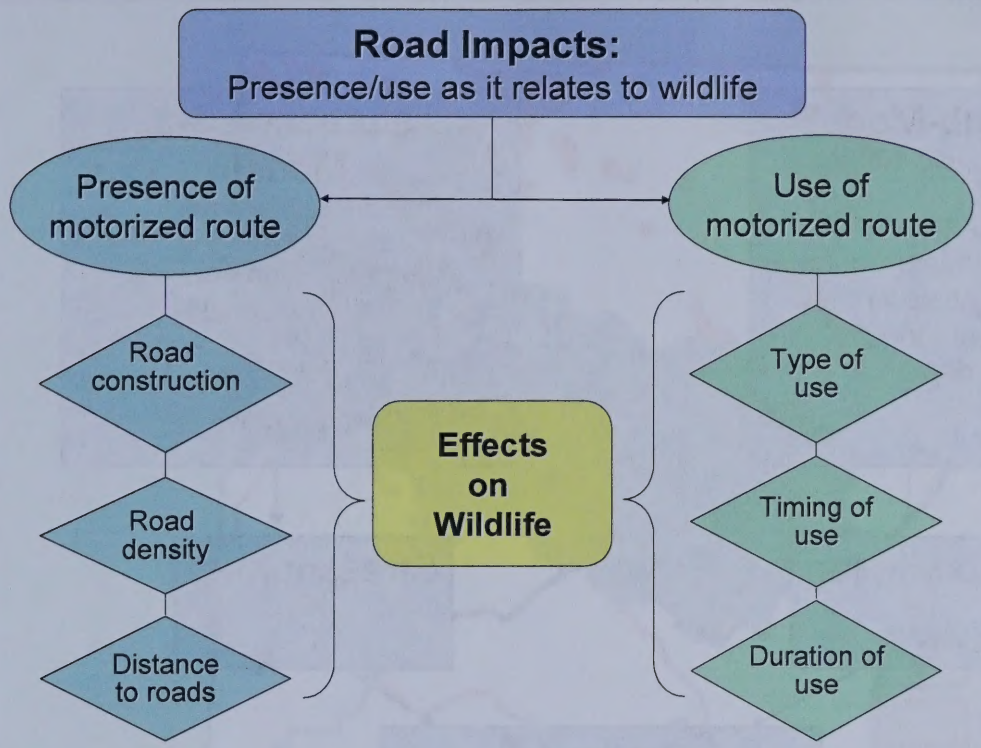


Figure 18. Conceptual sub-model for the effects of roads on wildlife. Two primary components of road impacts: presence (blue) and use (green) of roads are represented. Effects are considered both spatially and temporally.

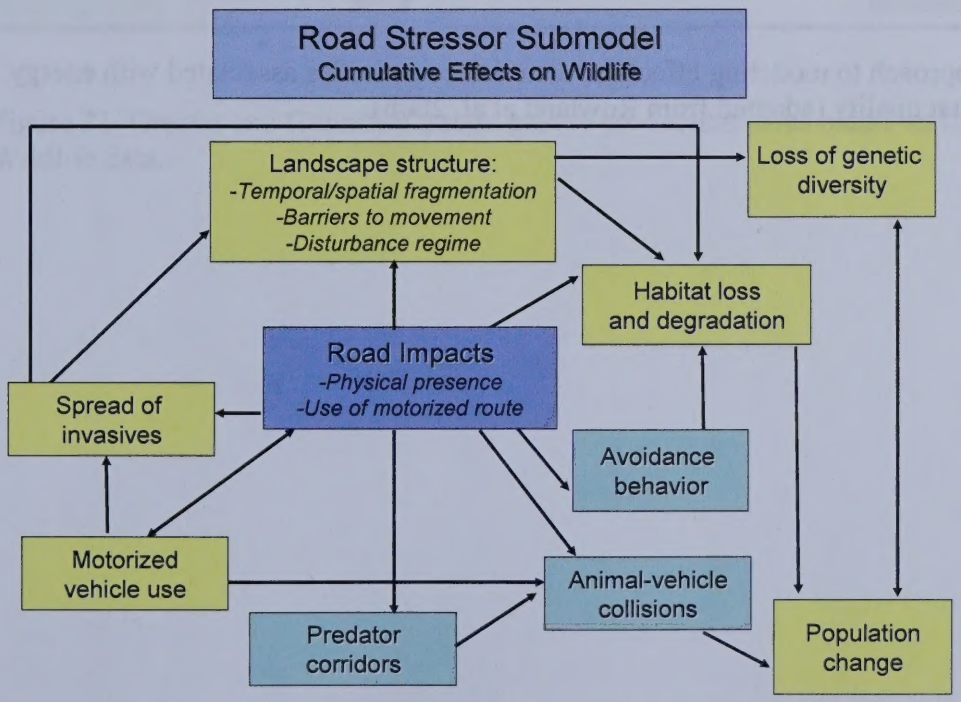


Figure 19. Conceptual sub-model for the effects of roads on wildlife. Possible mechanisms are indicated in blue rectangles. Yellow rectangles represent additional mechanisms and potential indicators.

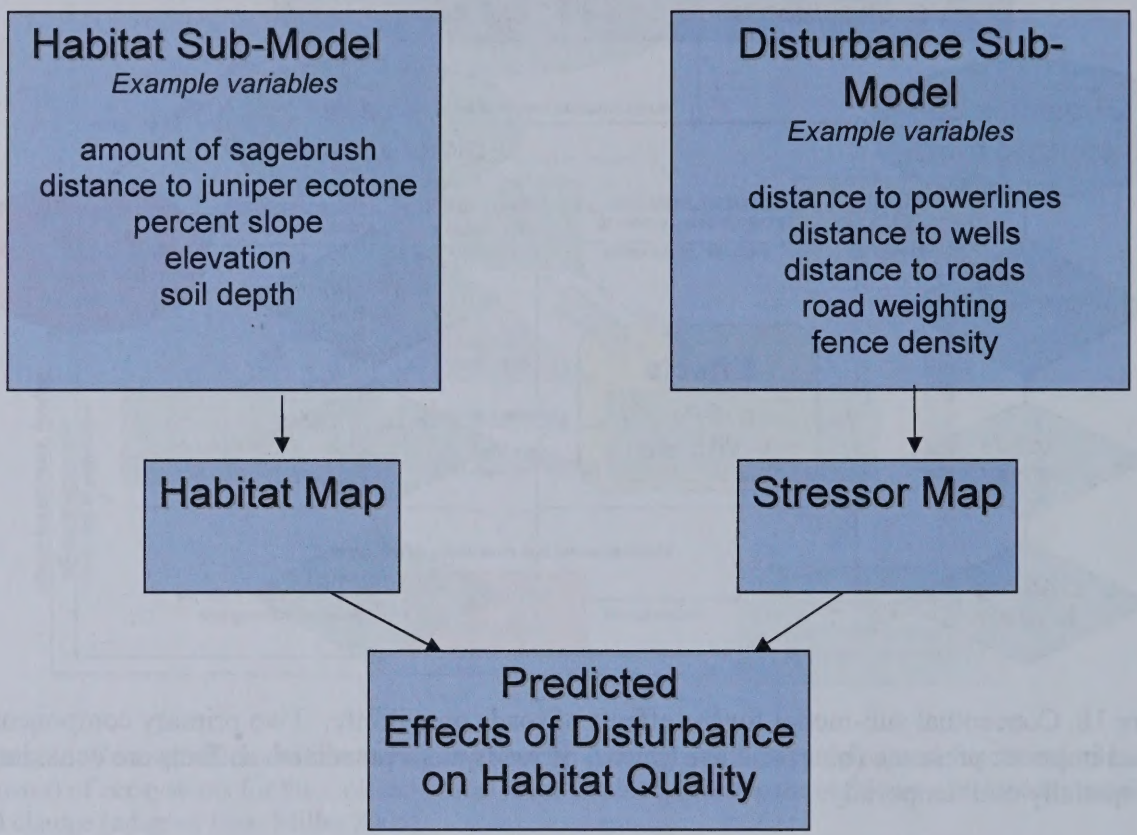


Figure 20. Overall approach to modeling effects of disturbance activities associated with energy development on habitat quality (adapted from Rowland et al. 2006).

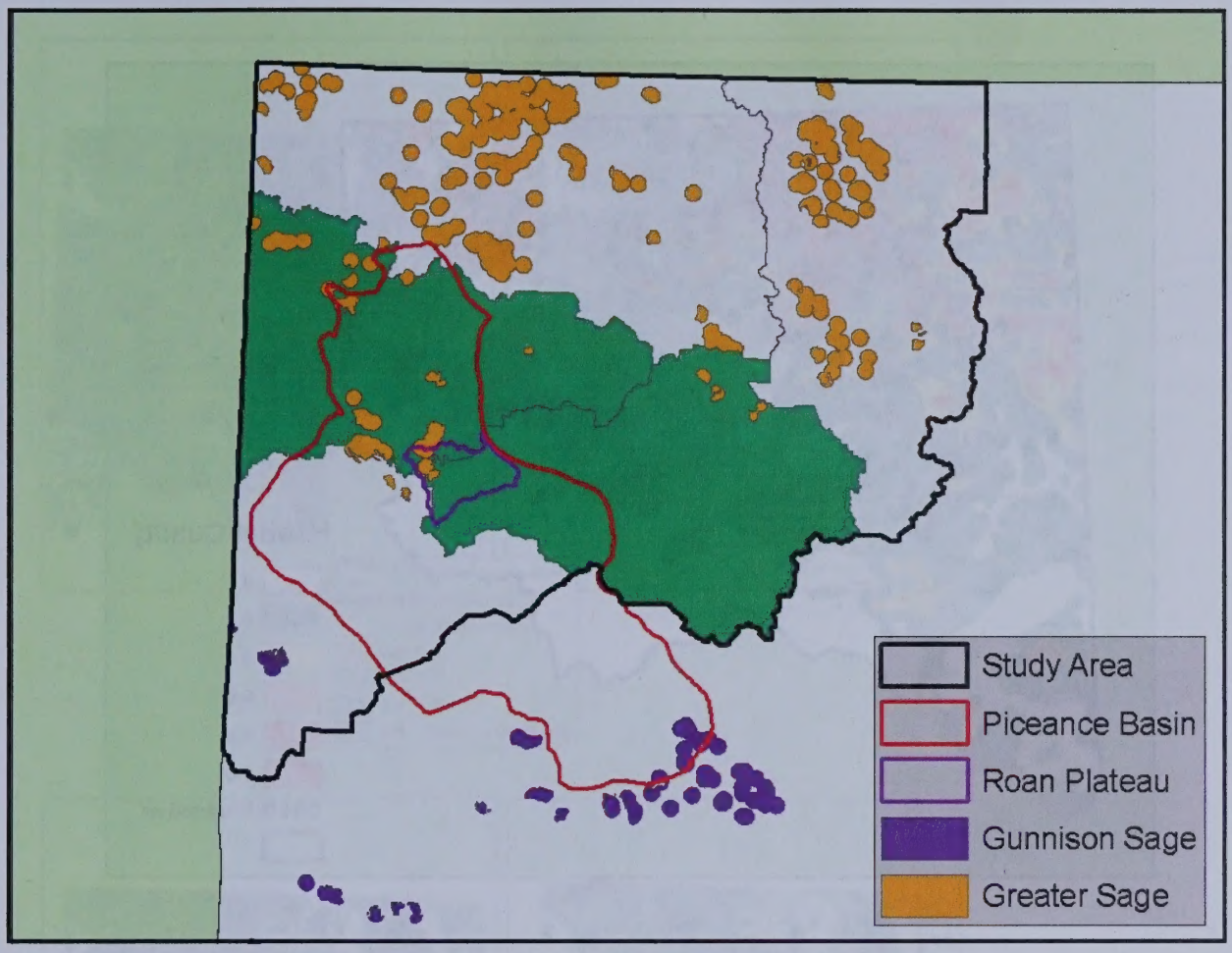


Figure 21. Greater and Gunnison's sage-grouse production areas based on Colorado Division of Wildlife data.

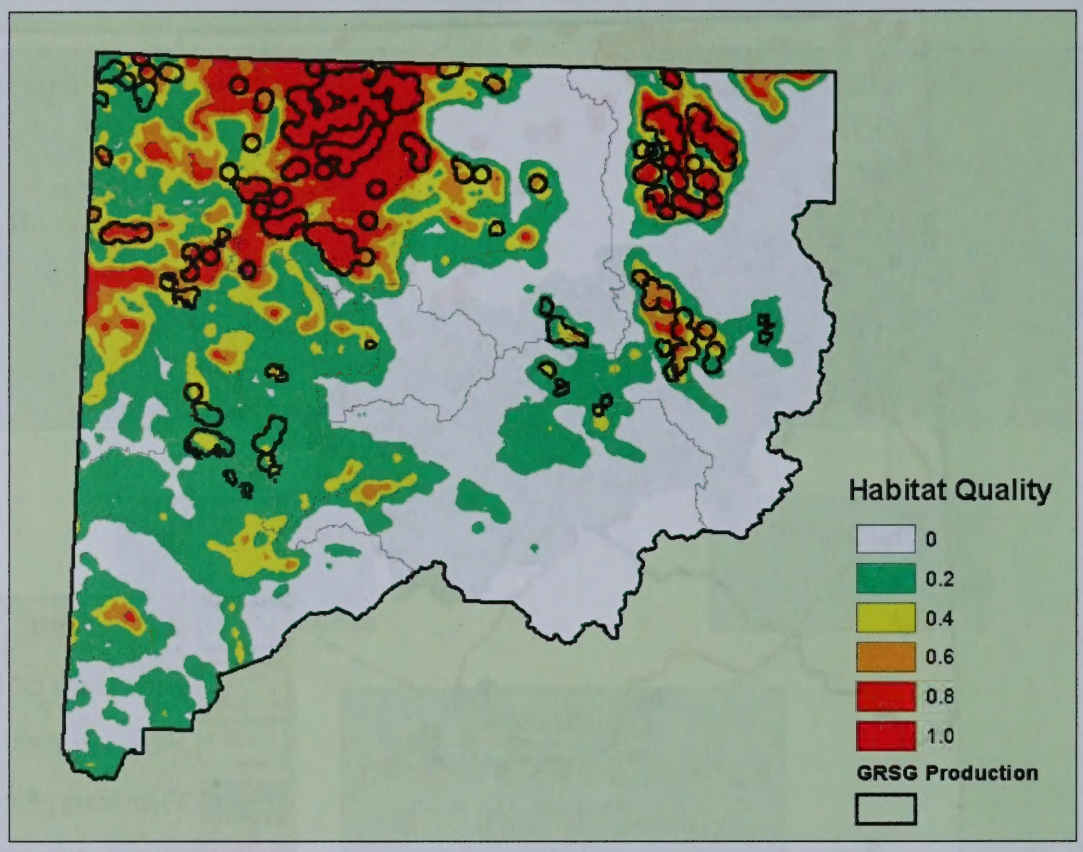


Figure 22. Map of greater sage-grouse habitat quality in comparison to known production areas (Colorado Division of Wildlife data).

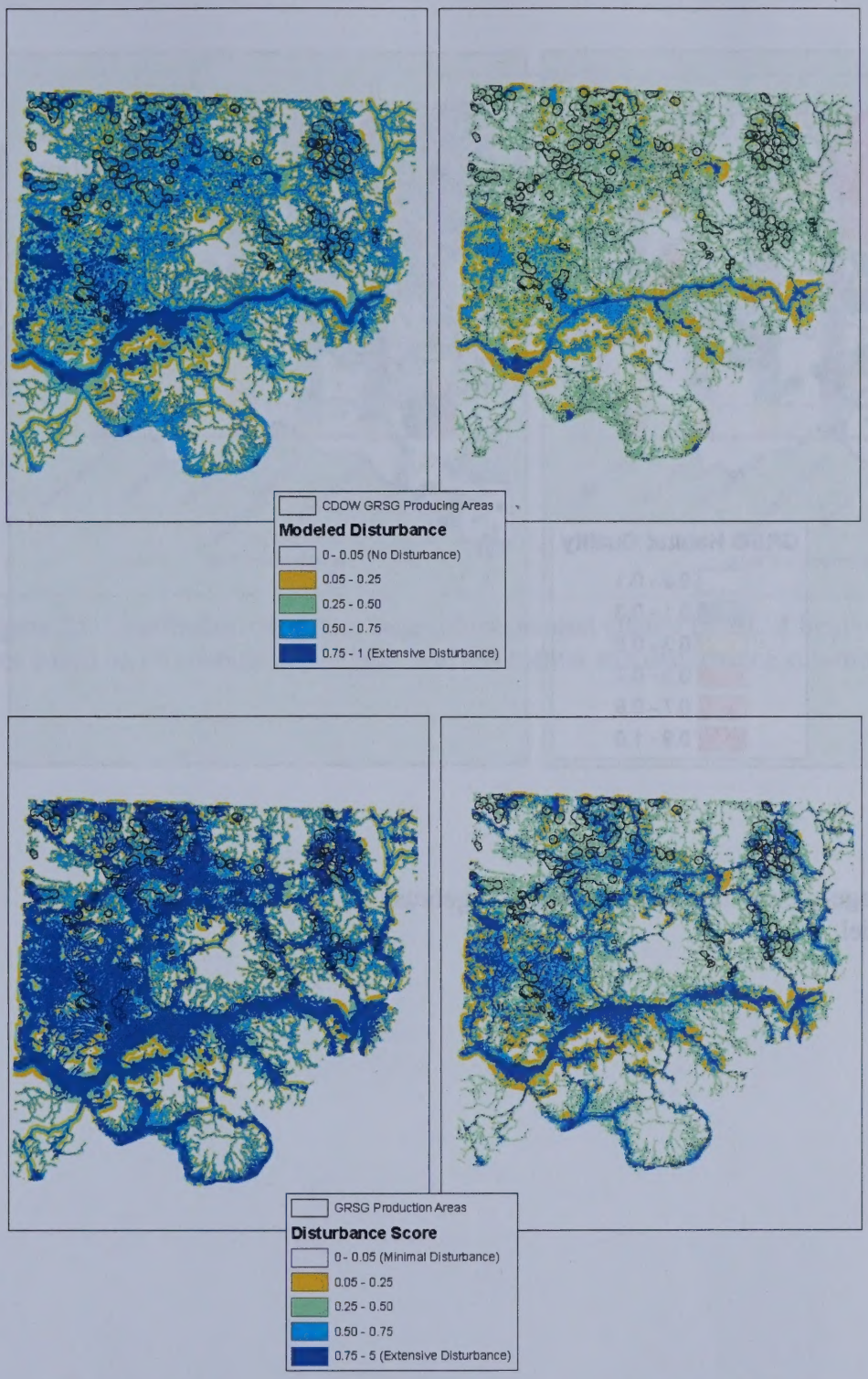


Figure 23. Results of greater sage-grouse disturbance sub-model. A) Original model with maximum overall score, B) revised disturbance values and maximum overall score, C) original disturbance values and additive overall score, and D) revised disturbance values and additive overall score.

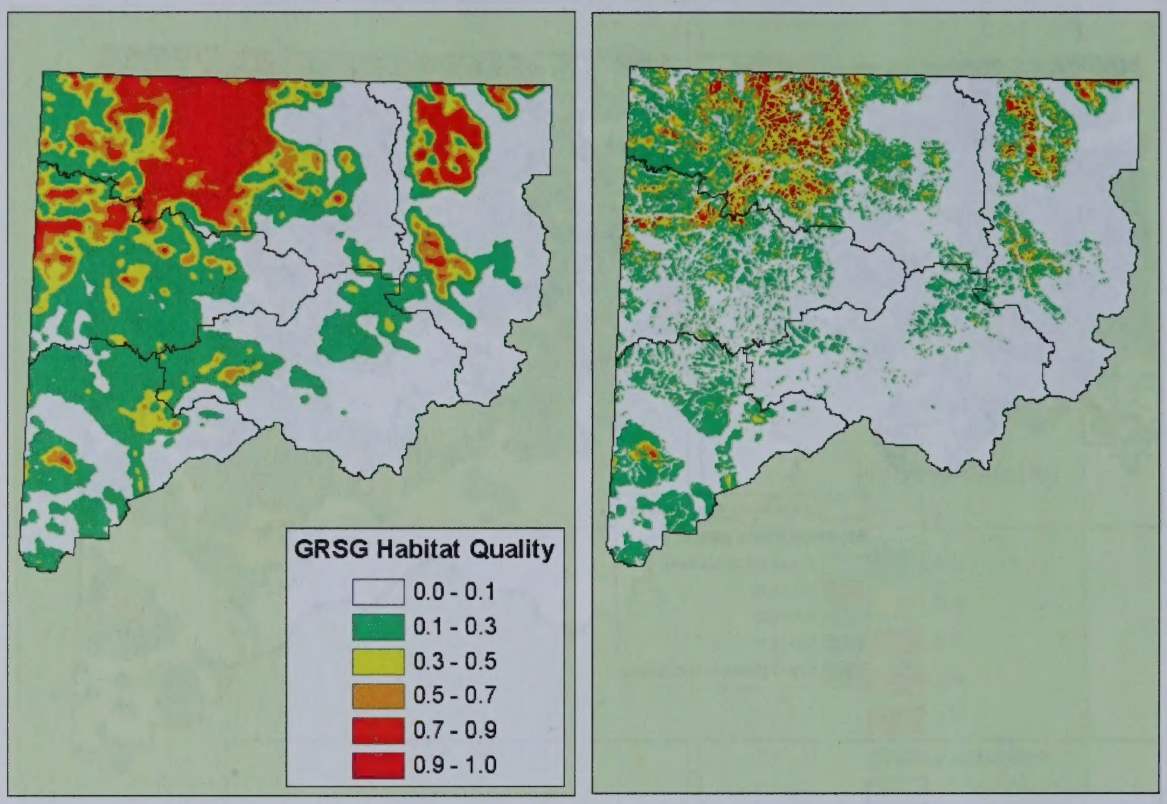


Figure 24. Greater sage-grouse habitat based on (A) sagebrush cover only and (B) including disturbance sub-model.

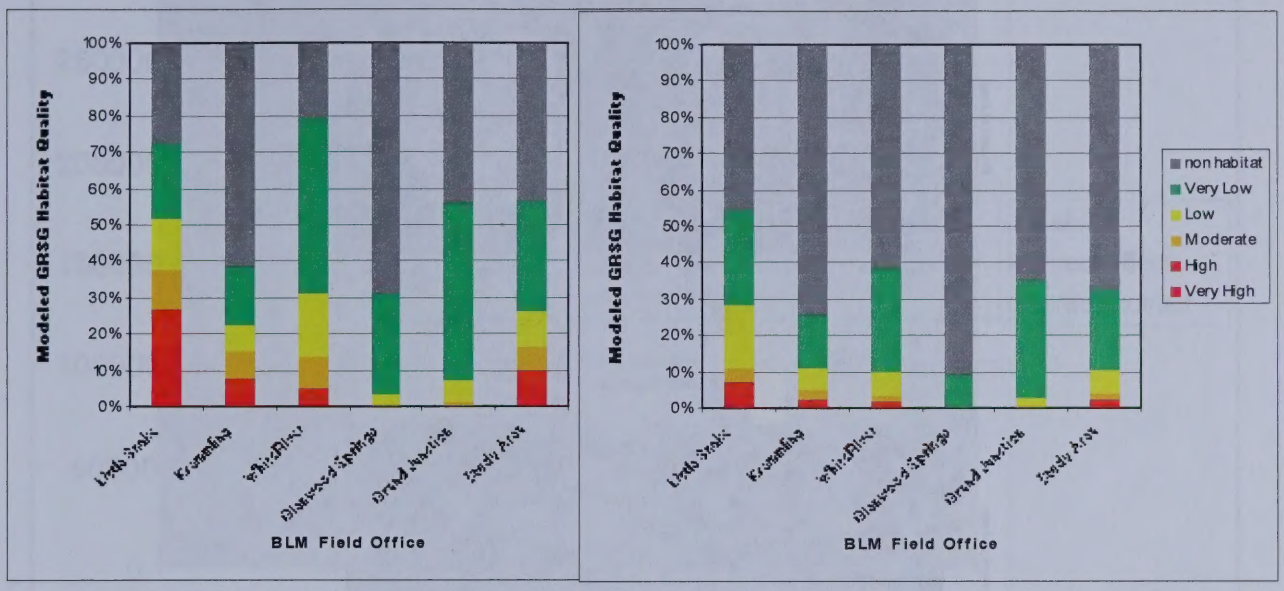
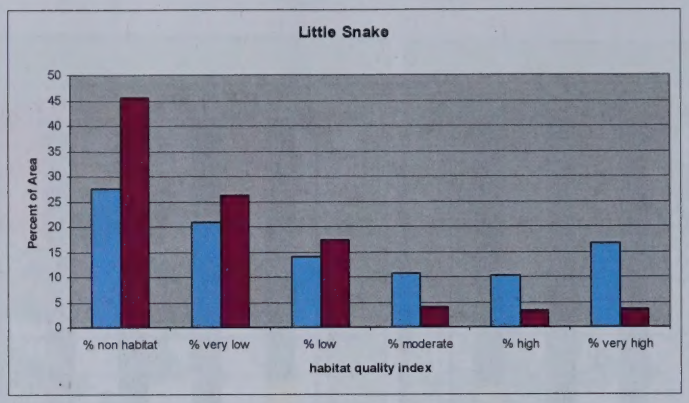
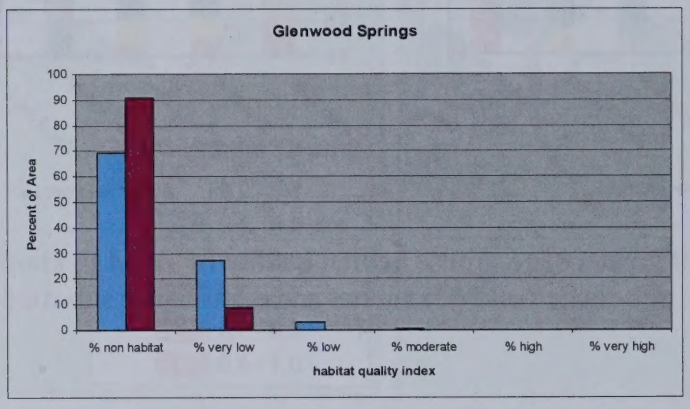
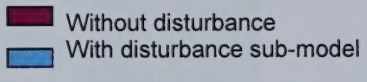
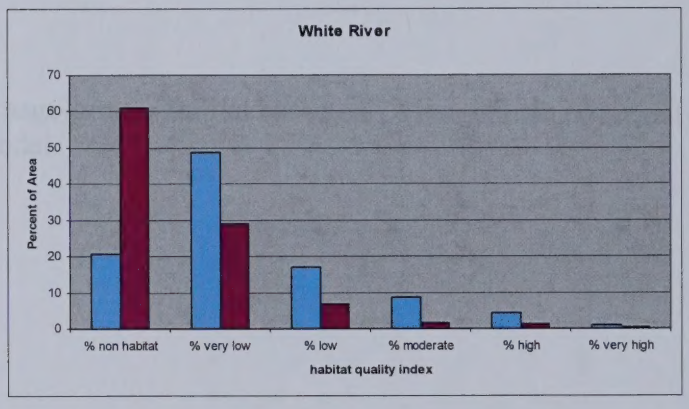


Figure 25. Distribution of greater sage-grouse habitat quality by BLM field office for the study area based on (A) habitat sub-model, and (B) habitat and disturbance sub-models.









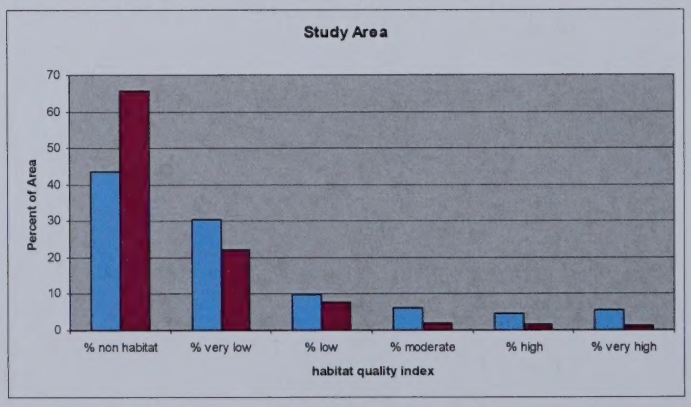


Figure 26. Greater sage-grouse habitat quality with and without disturbance (direct and indirect effects) for select field offices and the entire study area.

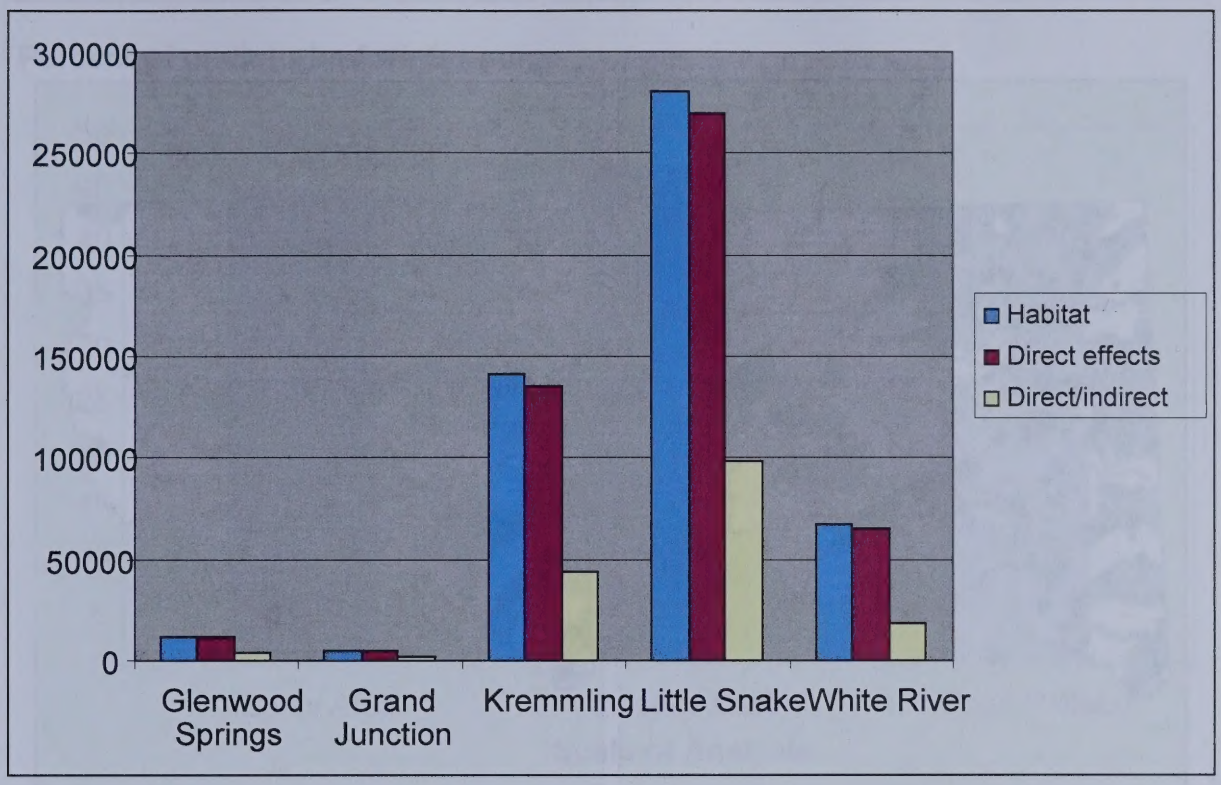


Figure 27. Total area of greater sage-grouse habitat by BLM field office. "Habitat" is based on vegetation sub-model only. "Direct effects" includes the loss of habitat due to roads and other surface disturbance and was assumed to be up to 45 m from the road center. "Direct/indirect" includes the additional decrease in habitat quality due to indirect effects surface disturbance.

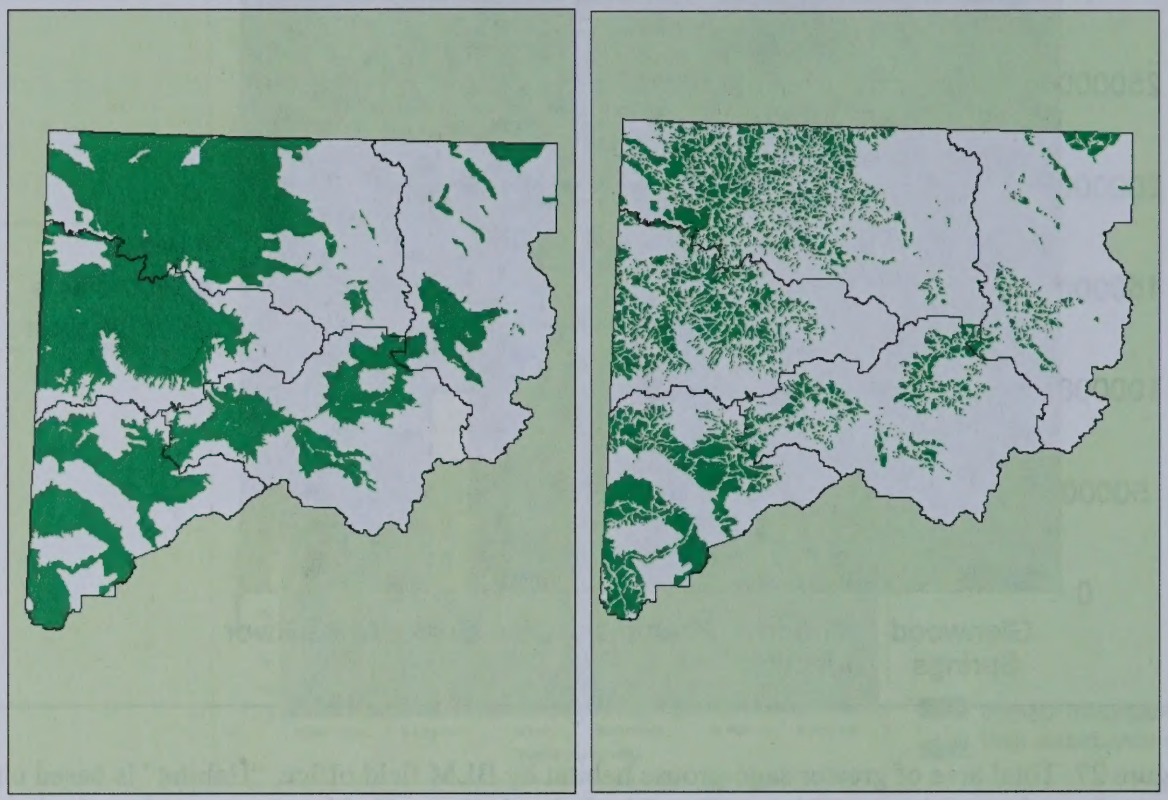


Figure 28. Mule deer winter range based on (A) Colorado Division of Wildlife data (B) including the disturbance sub-model (> 500 m from roads; > 50 ha).

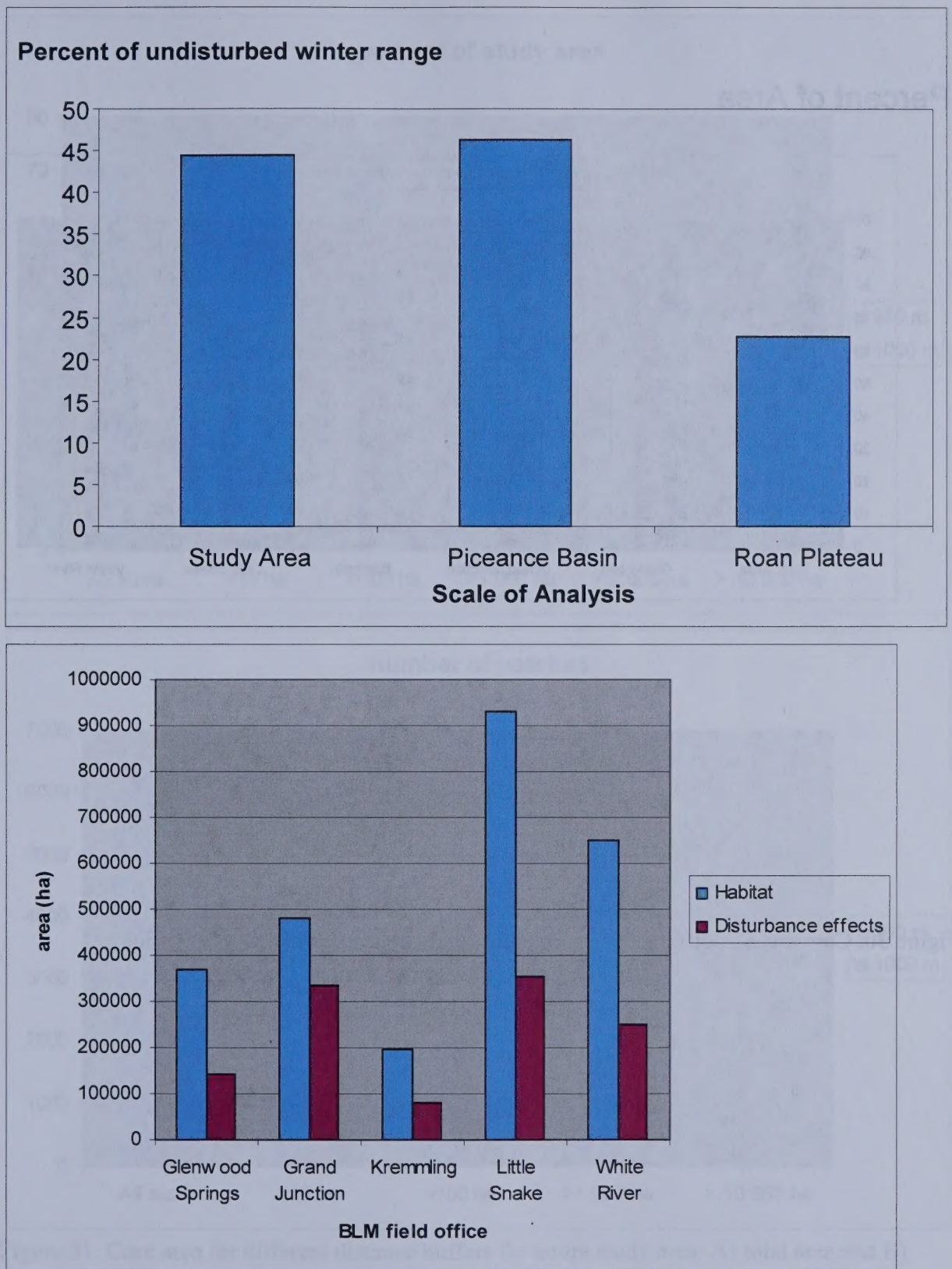


Figure 29. A) Percent of undisturbed mule deer winter range at each scale of analysis; B) winter habitat for mule deer with and without disturbance effects by BLM field office.

Percent of Area

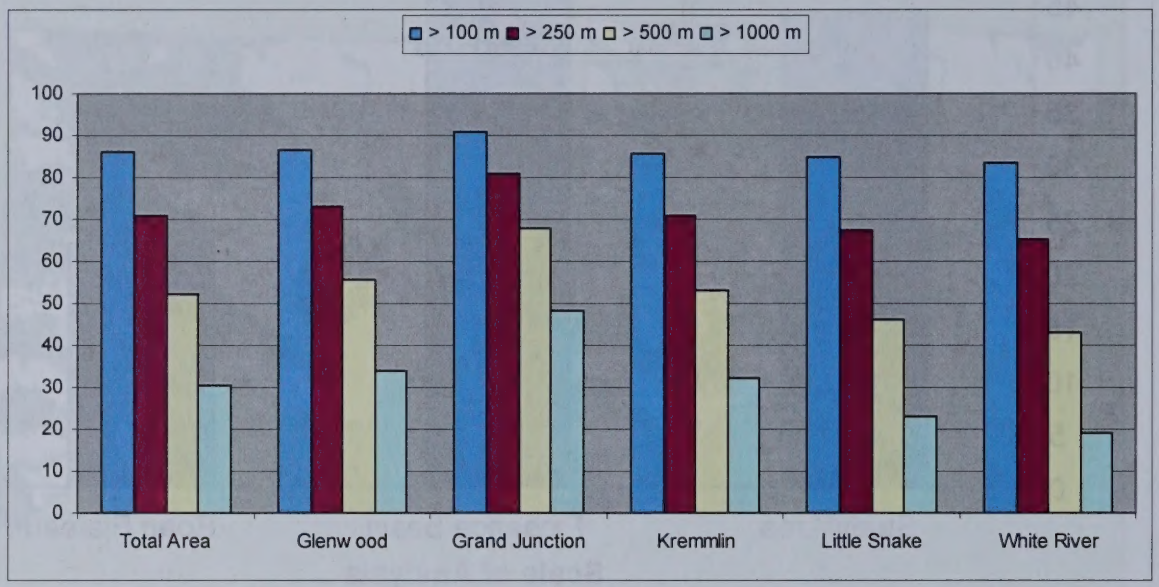


Figure 30. Core areas of different sizes for entire study area and by BLM field office.

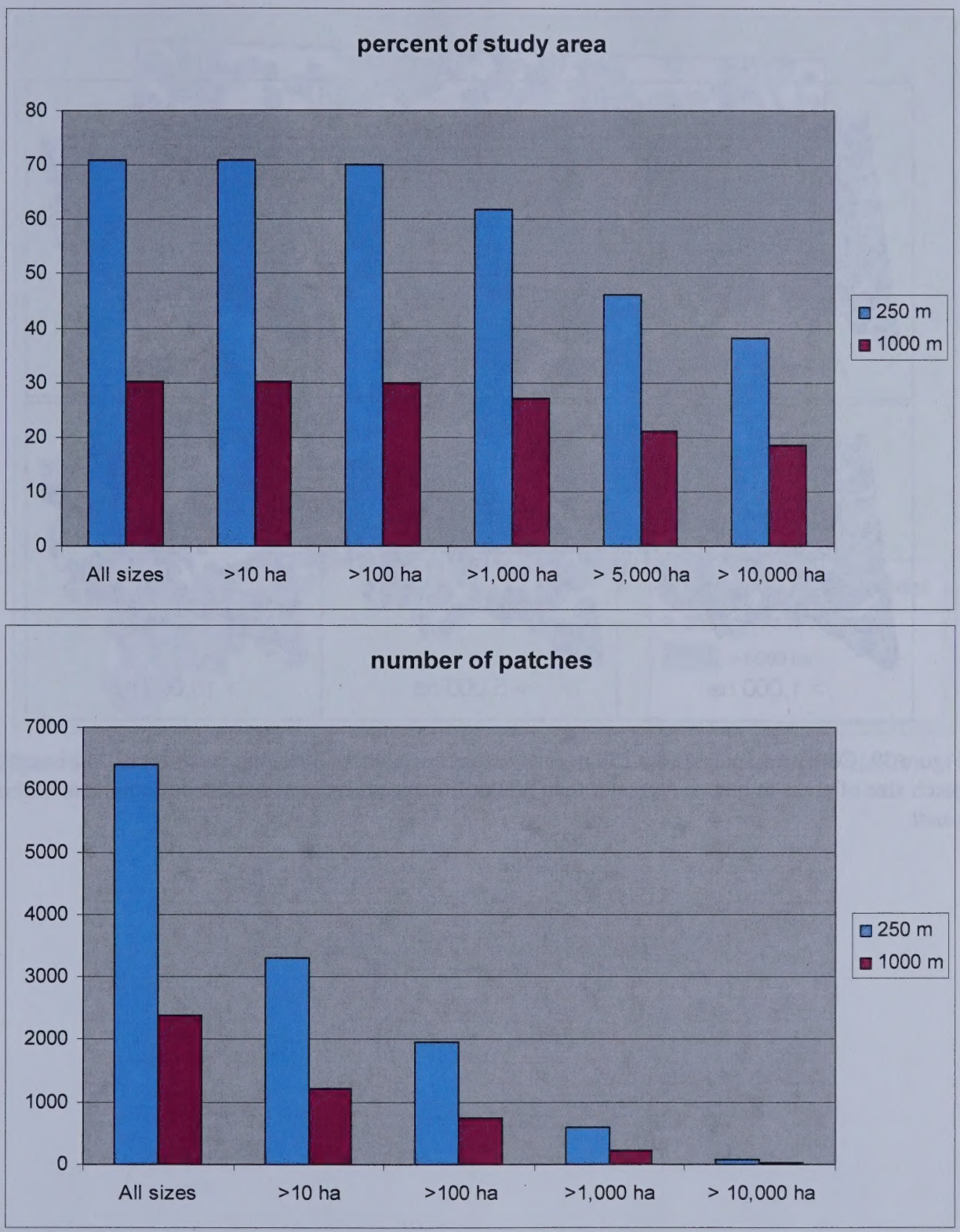


Figure 31. Core area for different distance buffers for entire study area: A) total area and B) number of patches for each buffer size.

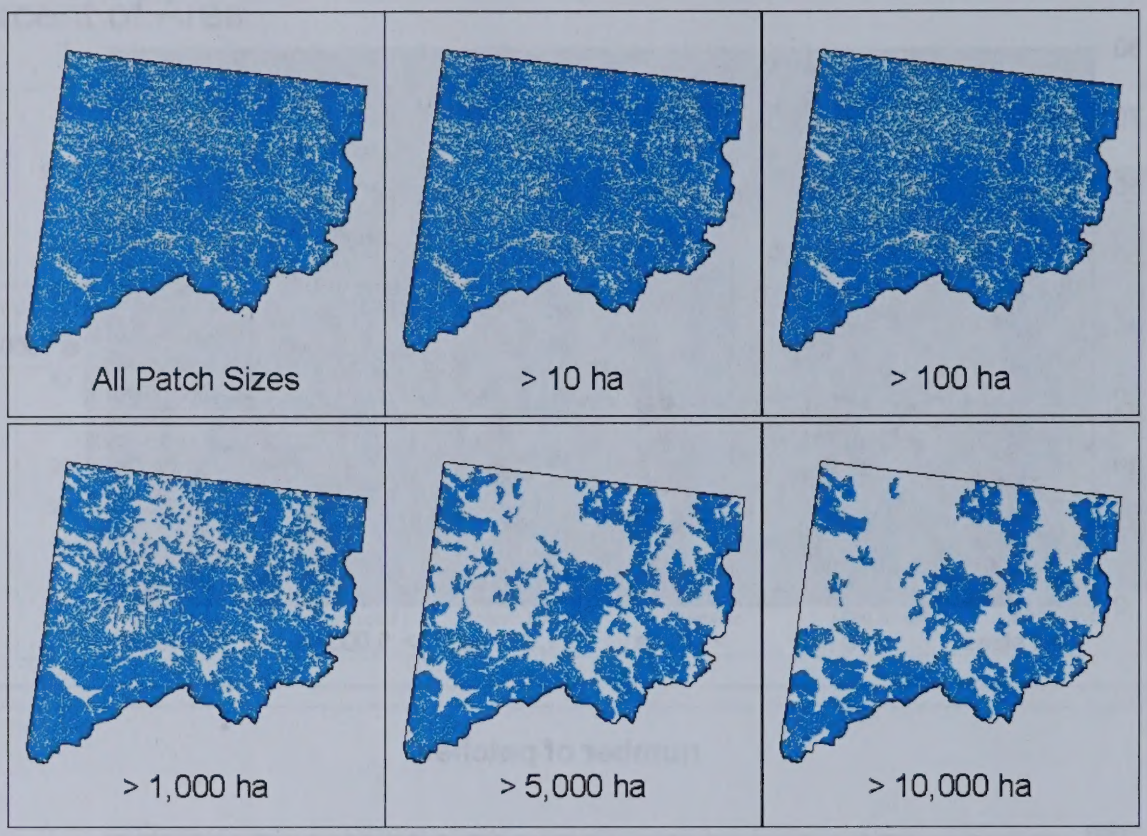


Figure 32. Core area analysis for 250 m road disturbance buffer for entire study area. Minimum patch size of areas in blue and greater than 250 m from roads indicated at the bottom of each panel.

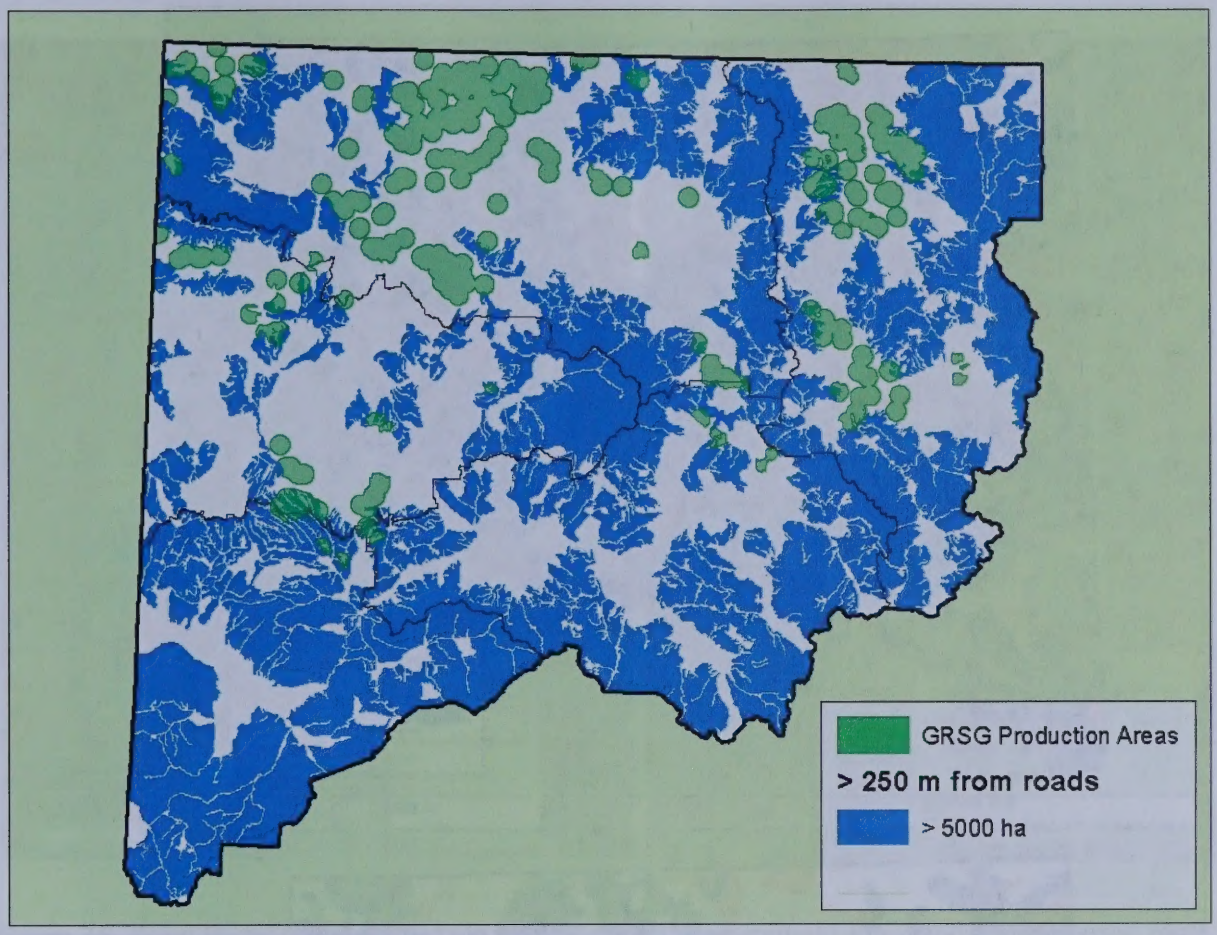


Figure 33. Location of greater sage-grouse production areas (Colorado Division of Wildlife) relative to patches > 250 m from roads and > 5000 ha.

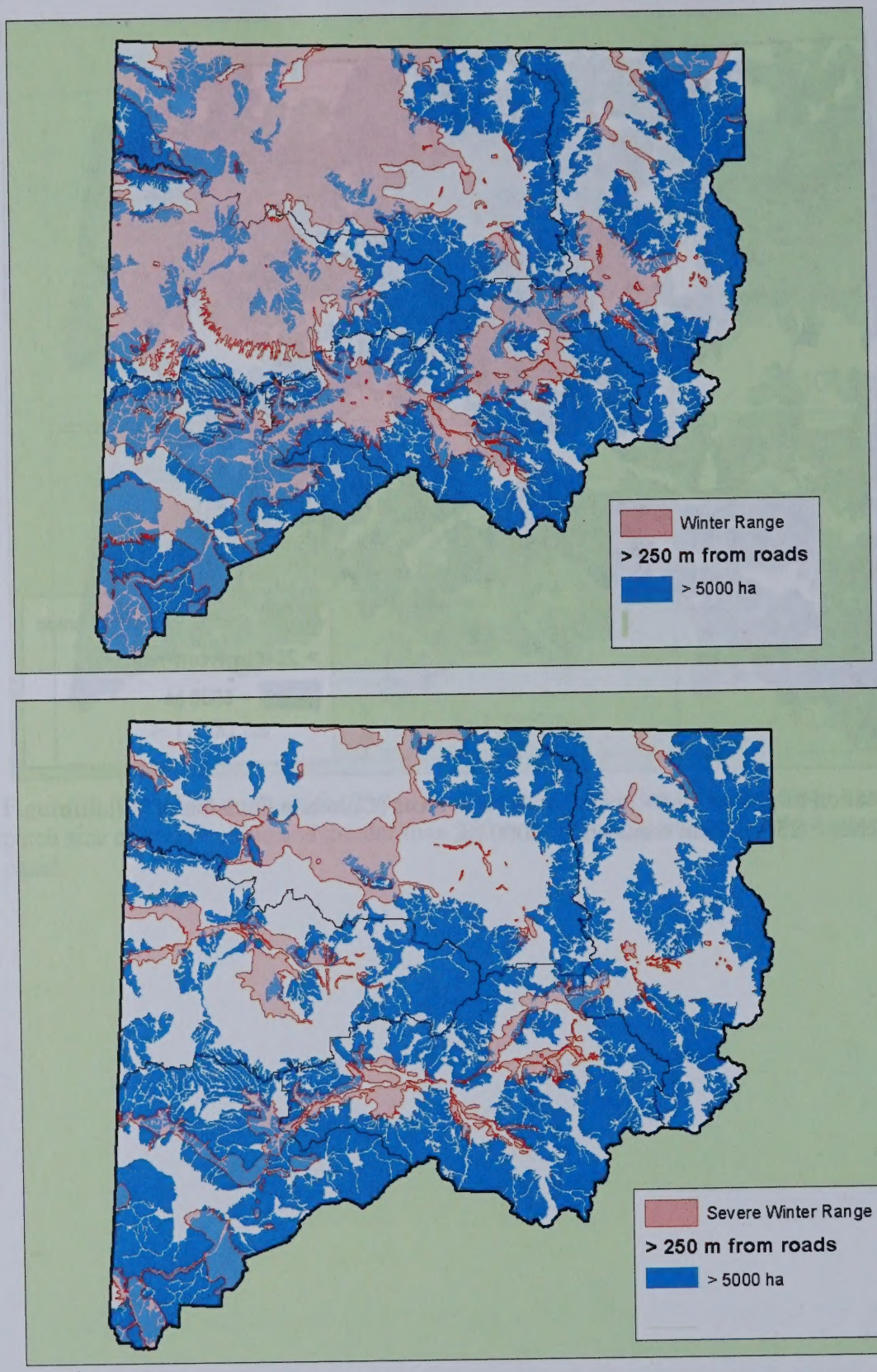


Figure 34. Location of mule deer winter range (Colorado Division of Wildlife) relative to patches > 250 m from roads and > 5000 ha: (A) entire winter range and (B) severe winter range.

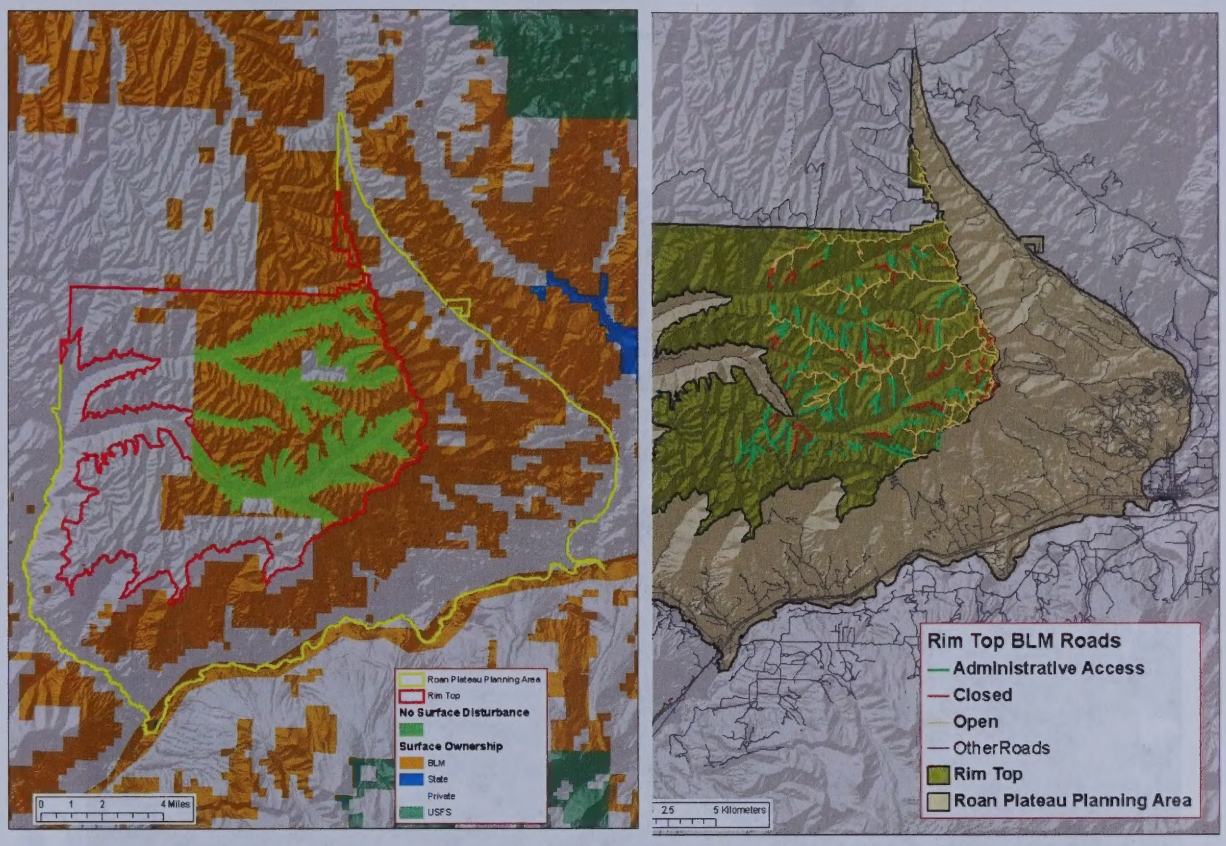


Figure 35. Roan Plateau Planning Area (A) Proposed Management Plan, and (B) proposed road closures/restrictions.

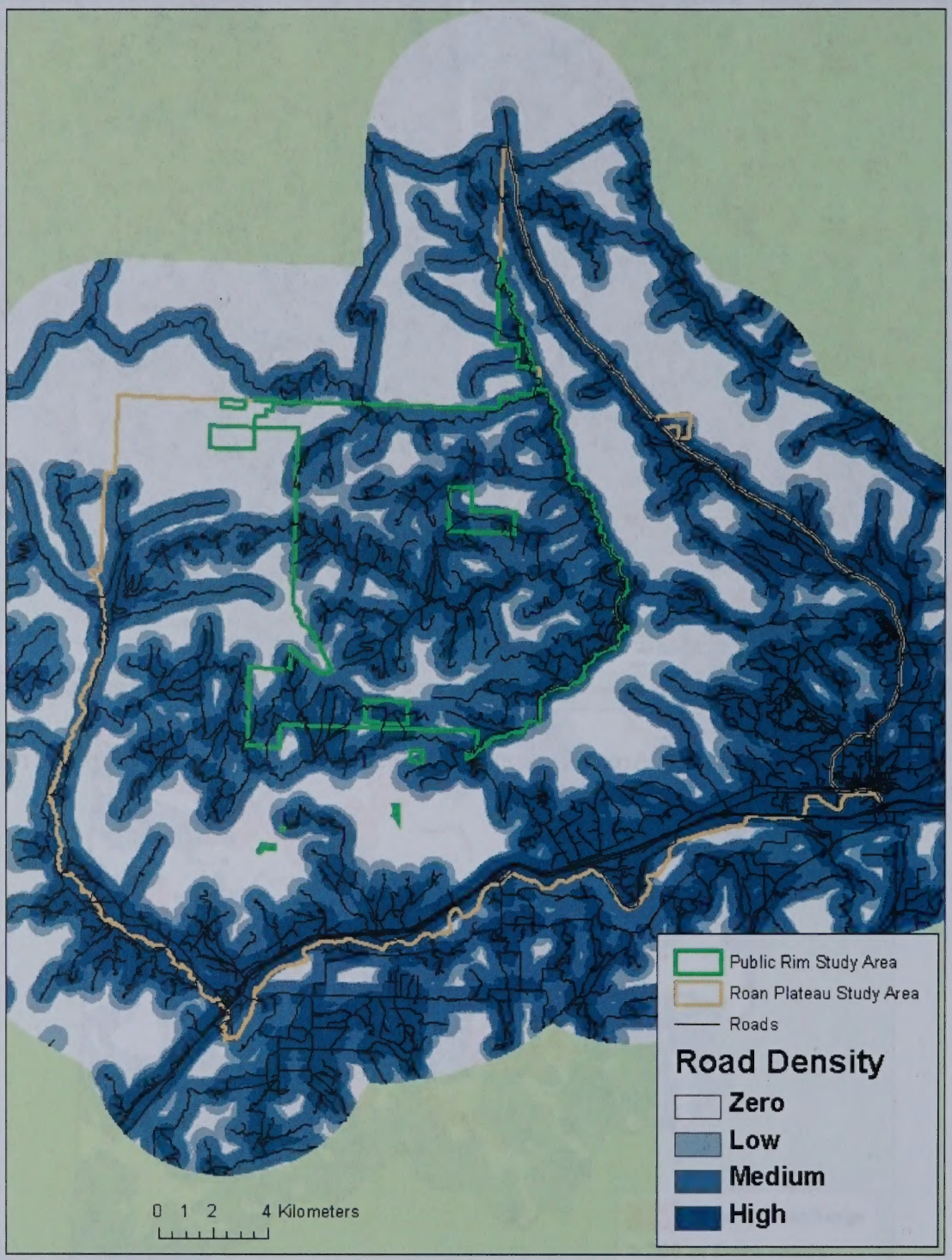


Figure 36. Road densities and core areas for Roan Plateau Management Area.

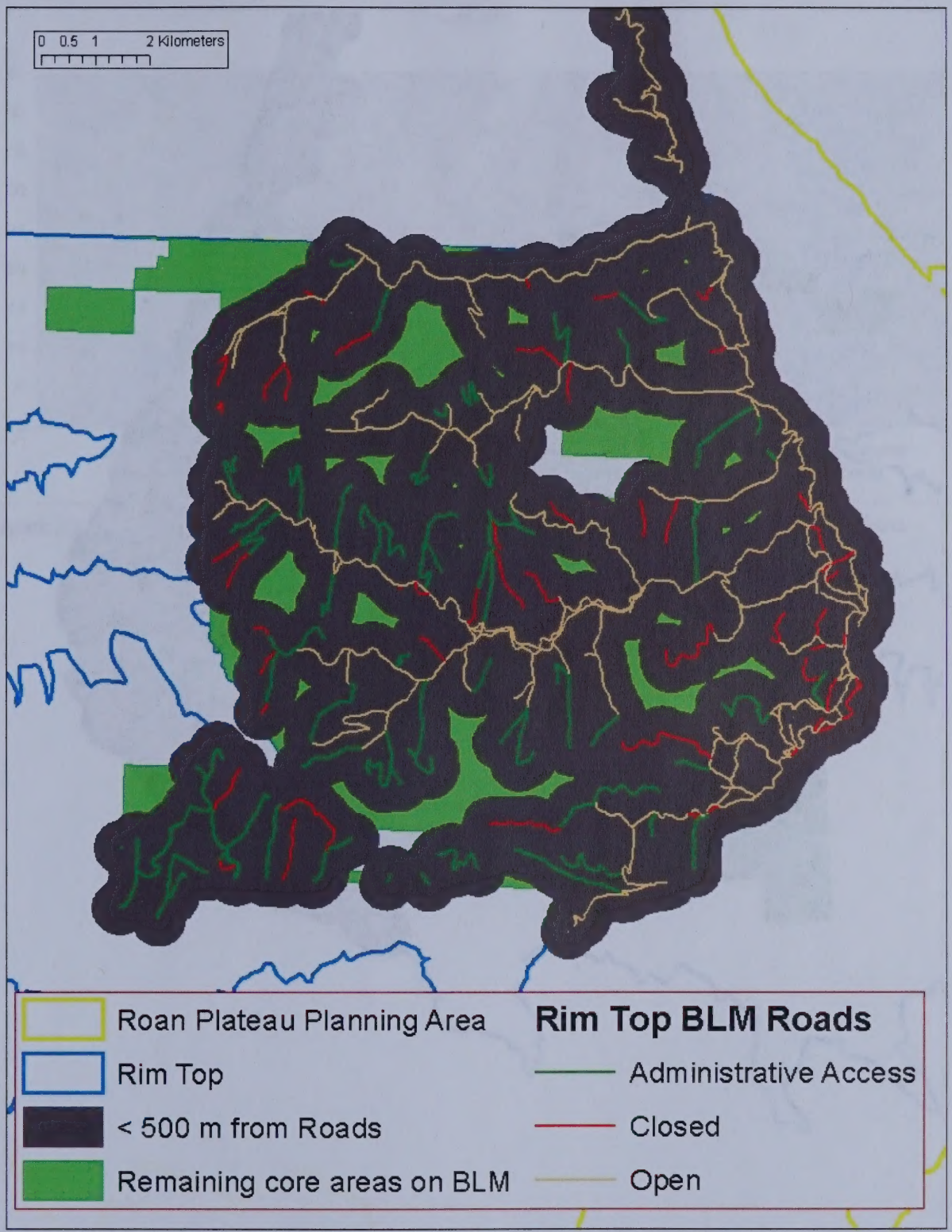


Figure 37. Core area analysis for Upper Roan Plateau based on existing roads.

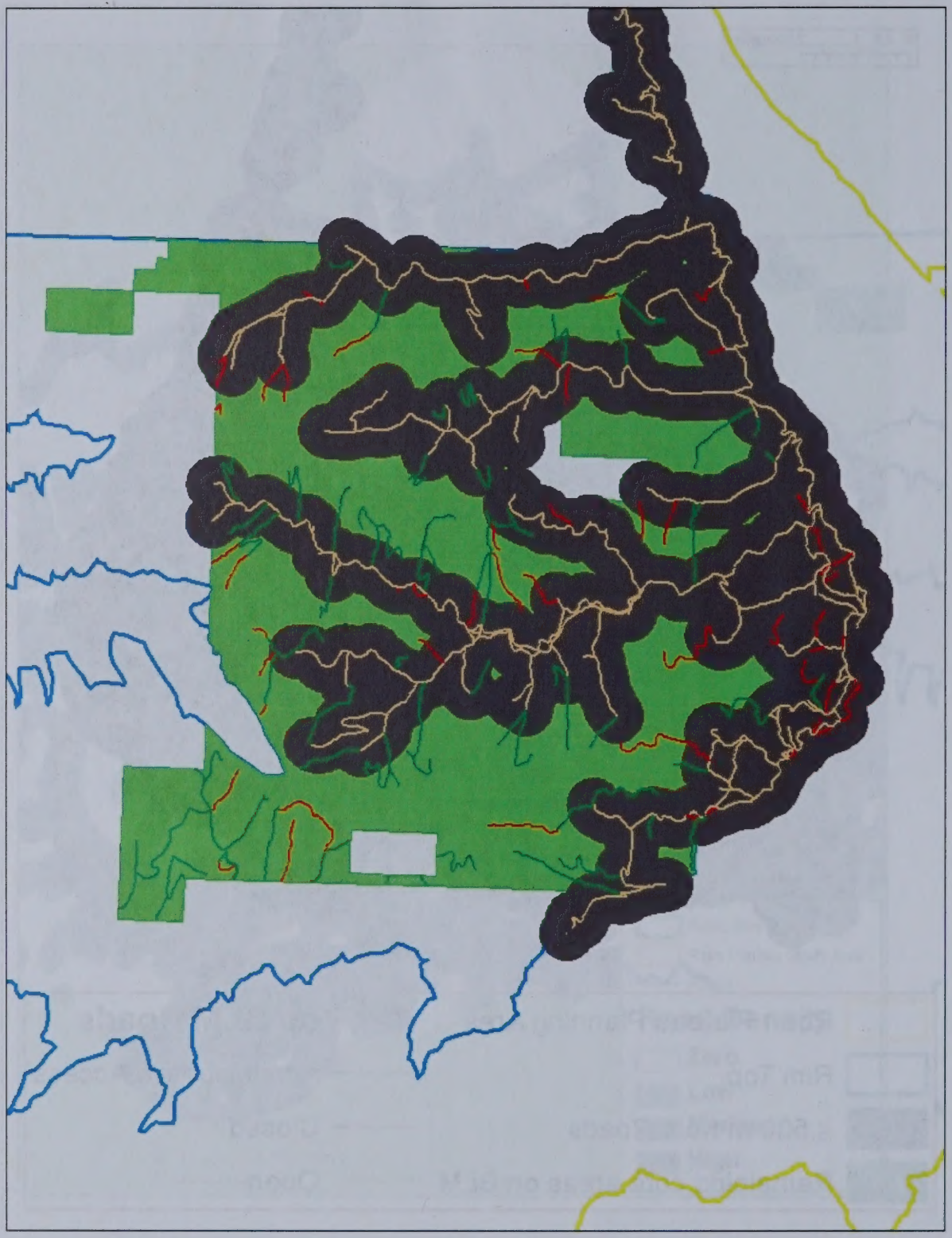


Figure 38. Core area analysis for Upper Roan Plateau based on projected road closures/restrictions.

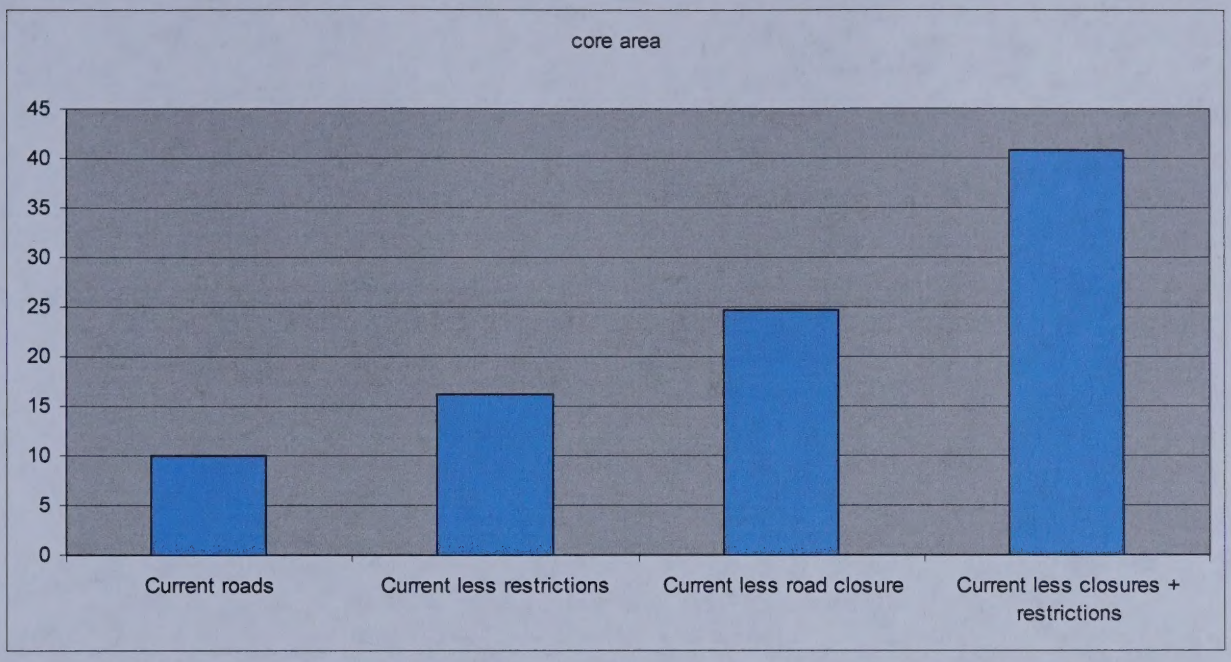


Figure 39. Core area analysis for several proposed road closures on the upper Roan Plateau.